BusWorks® XT Series for Modbus TCP/IP
USB Programmable
10/100MB Industrial Ethernet I/O Modules

Model XT1231-000 & XT1241-000
16-Channel Single-Ended Current Input
16-Channel Single-Ended Voltage Input

USER'S MANUAL

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IMPORTANT SAFETY CONSIDERATIONS

You must consider the possible negative effects of power, wiring, component, sensor, or software failure in the design of any type of control or monitoring system. This is very important where property loss or human life is involved. It is important that you perform satisfactory overall system design and it is agreed between you and Acromag, that this is your responsibility.

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GETTING STARTED

DESCRIPTION

Symbols on equipment:

Means “Refer to User’s Manual (this manual) for additional information”.

The XT1231-000 and XT1241-000 are Modbus TCP/IP network modules for interface with up to 16 Single-Ended channels of DC current input (XT1231-000), or 16 Single-Ended channels of DC voltage input (XT1241-000). These units are conveniently setup and configured for network communication via a USB connection to any Windows-based PC (Windows XP and later versions only). They provide input isolation from network & power.

Key Features

- **CE Approved, UL/cUL Class I, Division 2.**
- **Designed and Manufactured with High Quality/High Reliability with AS9100 (Aerospace Quality)/ISO9001.**
- **Modbus TCP/IP Protocol Support and w/ i2o Messaging Support.**
- **Conveniently setup and configured w/ Windows software via USB.**
- **High-Density 22.5mm wide package with pluggable, front-facing terminals.**
- **Dual Isolated 10/100Mbps Ethernet ports w/ Auto-Negotiation offers convenient “daisy chain” network connection which saves switch ports.**
- **Operation & Diagnostic LED indicators aide trouble-shooting.**
- **Bus Power Ready for Clean Wiring along the DIN Rail, or for Redundant Power Connection.**
- **High 1500VAC Isolation between input channels (as a group), the network (including port-to-port), and power.**
- **Input, power, network, and USB ports are all transient protected.**
- **Wide-range DC power input from 12-32V.**
- **Wide ambient temperature operation from -40°C to +70°C.**
- **Thoroughly Tested and Hardened For Harsh Environments.**
- **Withstands High Shock (25G) and Vibration (4G).**

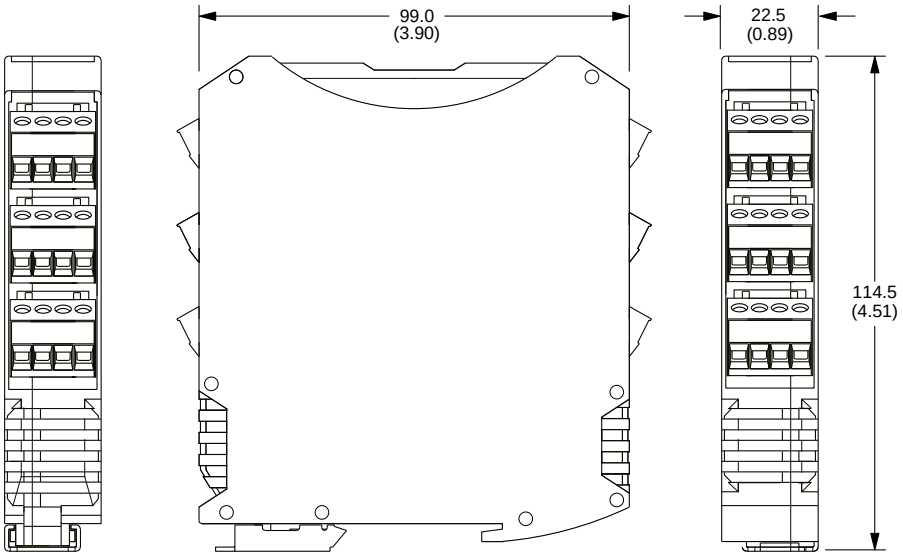
Application

This module is designed for high-density mounting on T-type DIN rails. XT models may be mounted side-by-side on 22.5mm centers and can plug-together for modular expansion with a shared power connection along the DIN rail. Units are conveniently setup and configured for network operation via a USB connection to a host computer running Acromag configuration software. These models will interface with any mix of up to 16 Single-Ended current inputs (Model XT1231-000), or 16 Single-Ended voltage inputs (Model XT1241-000), and monitor the input values via a 10/100Mbps Ethernet interface using the Modbus TCP/IP application protocol. These models also support i2o messaging over the network, which can link analog inputs of these models to analog outputs on another unit.

Mechanical Dimensions

Units may be mounted to 35mm "T" type DIN rail (35mm, type EN50022), and side-by-side on 22.5mm (0.9-inch) centers.

WARNING: *IEC Safety Standards may require that this device be mounted within an approved metal enclosure or sub-system, particularly for applications with exposure to voltages greater than or equal to 75VDC or 50VAC.*

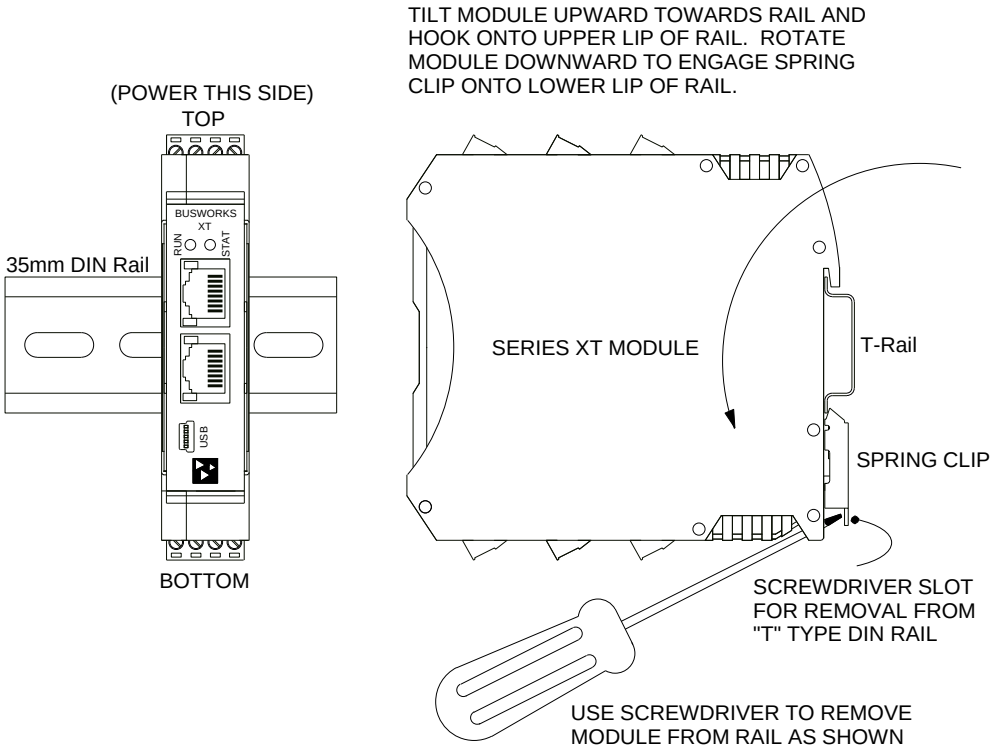


DIMENSIONS ARE IN MILLIMETERS (INCHES)

DIN Rail Mounting & Removal

Refer to the following figure for attaching and removing a unit from the DIN rail. A spring loaded DIN clip is located on the bottom side. The opposite rounded edge at the bottom of the top side allows you to tilt the unit upward to lift it from the rail, while prying the spring clip back with a screwdriver. To attach the module to T-type DIN rail, angle the top of the unit towards the rail and place the top groove of the module over the upper lip of the DIN rail. Firmly push the unit downward towards the rail until it snaps into place. To remove it from the DIN rail, first separate the input terminal blocks from the bottom side of the module to create a clearance to the DIN mounting area. You can use a screwdriver to pry the pluggable terminals out of their sockets. Next, while holding the module in place from above, insert a screwdriver along the bottom side path of the module to the DIN rail clip and use it as a lever to force the DIN rail spring clip down while pulling the bottom of the module outward until it disengages from the rail. Tilt it upward to lift it from the rail.

SERIES XT MODULE DIN RAIL MOUNTING AND REMOVAL


TILT MODULE UPWARD TOWARDS RAIL AND HOOK ONTO UPPER LIP OF RAIL. ROTATE MODULE DOWNWARD TO ENGAGE SPRING CLIP ONTO LOWER LIP OF RAIL.
(POWER THIS SIDE)
TOP
BUSWORKS
XT
RUN
STAT
USB
35mm DIN Rail
BOTTOM
SERIES XT MODULE
T-Rail
SPRING CLIP
SCREWDRIVER SLOT FOR REMOVAL FROM "T" TYPE DIN RAIL
USE SCREWDRIVER TO REMOVE MODULE FROM RAIL AS SHOWN

ELECTRICAL CONNECTIONS

WARNING – EXPLOSION HAZARD – Do not disconnect equipment unless power has been removed or the area is known to be non-hazardous.

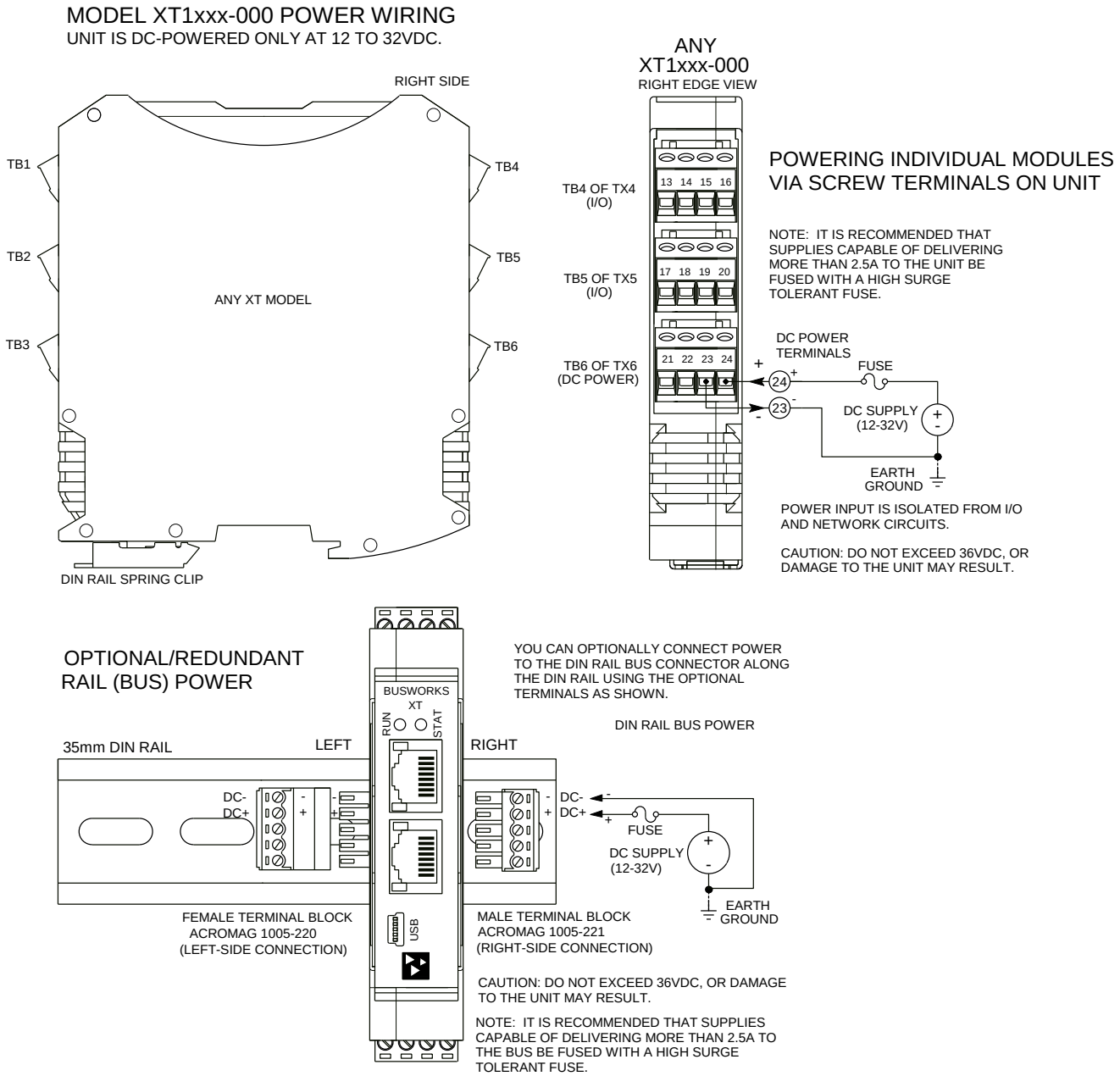
WARNING – EXPLOSION HAZARD – Substitution of any components may impair suitability for Class I, Division 2.

WARNING – EXPLOSION HAZARD – The area must be known to be non-hazardous before servicing/replacing the unit and before installing.

Wire terminals can accommodate 14-26 AWG solid or stranded wire. Input wiring may be shielded or unshielded type. Twisted pair input wiring is recommended. Terminals are pluggable and can be removed from their sockets by prying outward from the top with a flat-head screwdriver blade. Strip back wire insulation 0.25-inch on each lead and insert the wire ends into the cage clamp connector of the terminal block. Use a screwdriver to tighten the screw by turning it in a clockwise direction to secure the wire (use 0.5-0.6nM torque). Since common mode voltages can exist on I/O wiring, adequate wire insulation should be used and proper wiring practices followed. As a rule, input wires are normally separated from power and network wiring for safety and isolation, as well as for low noise pickup.

Power Connections

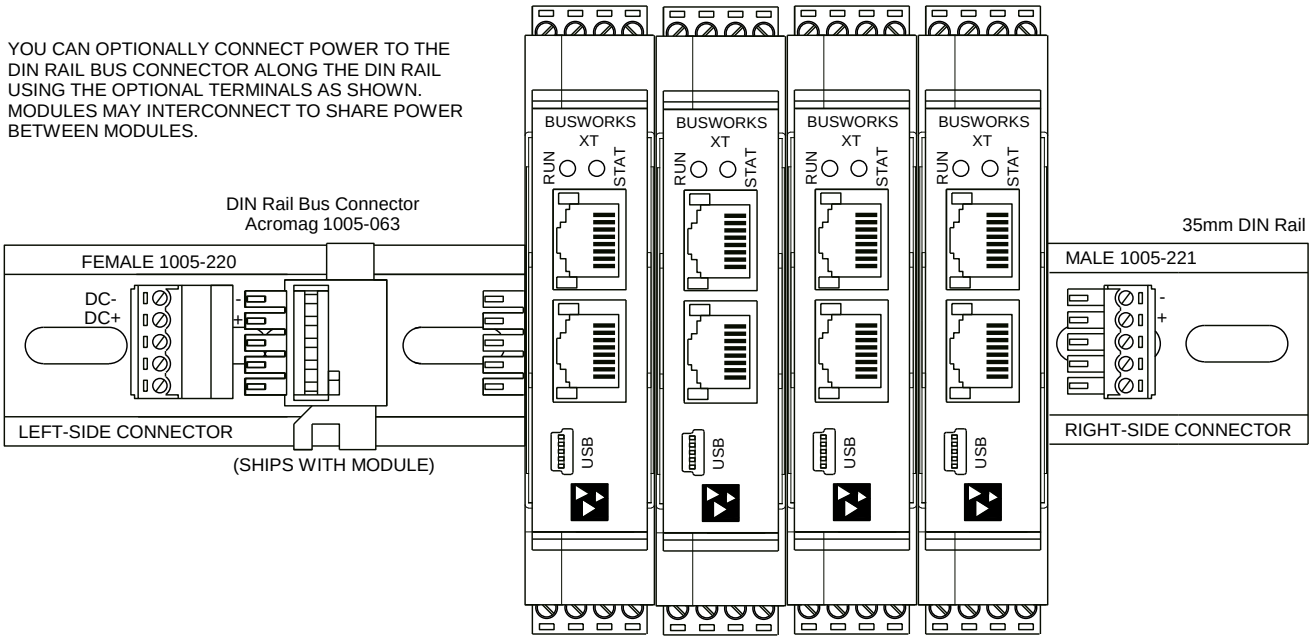
Connect a DC power supply from 12-32V as shown in the drawing below. Observe proper polarity (input power is reverse-polarity protected). Optionally, the unit may be powered (or redundantly powered) via its DIN rail connector (optional terminal required, see below). For supply connections, use 14 AWG wire rated for at least 80°C. Do not exceed 36V DC peak.



Power Connections…

Note that you can use the bus power connector of the module to interconnect modules by plugging them together and connecting them as a group to a suitable power supply using an optional left or right terminal block, 1005-220 or 1005-221, as shown below.

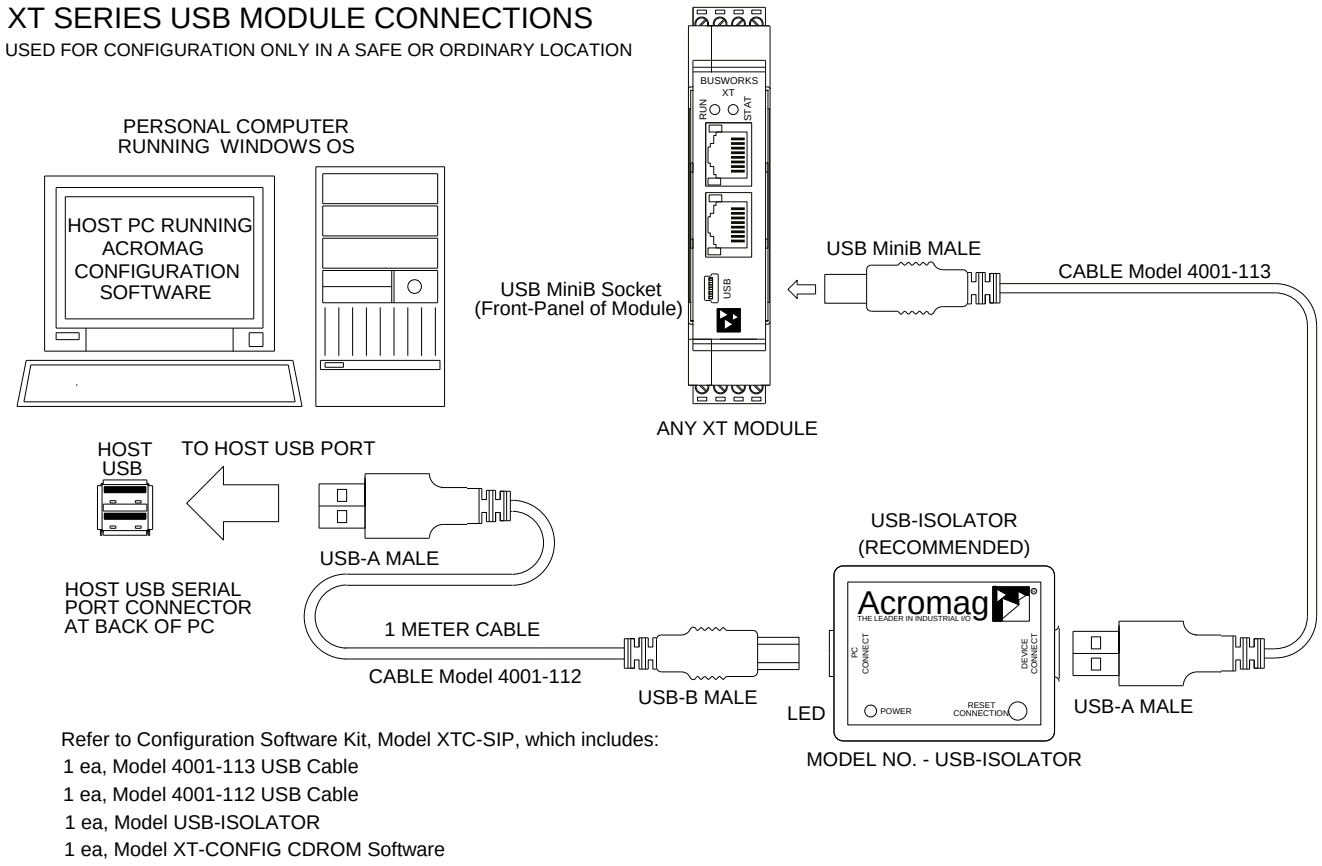
XT MODEL OPTIONAL BUS POWER WIRING



USB Connection

WARNING: The intent of mating USB with this unit is so that it can be conveniently setup and configured in a safe area, then installed in the field which may be in a hazardous area. Do not attempt to connect a PC or laptop to this unit while installed in a hazardous area, as USB energy levels could ignite explosive gases or particles in the air.

- **USB Signal Isolation Recommended -** You may use Acromag model USB-ISOLATOR to isolate your USB port, or you can optionally use another USB signal isolator that supports USB Full Speed operation (12Mbps).
- **Reconfiguration Does Not Require a Network Connection, as it uses a USB connection to configure the unit**.
- **Connect Unit to Power Before USB** – Unit does not use USB power.



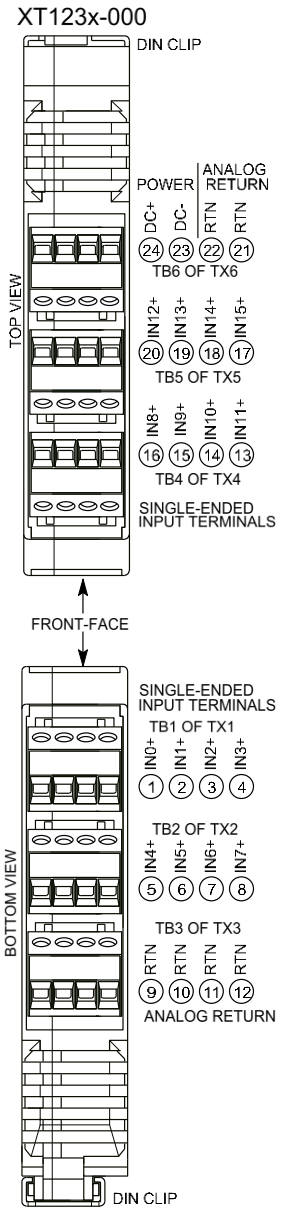
Refer to Configuration Software Kit, Model XTC-SIP, which includes:
1 ea, Model 4001-113 USB Cable
1 ea, Model 4001-112 USB Cable
1 ea, Model USB-ISOLATOR
1 ea, Model XT-CONFIG CDROM Software

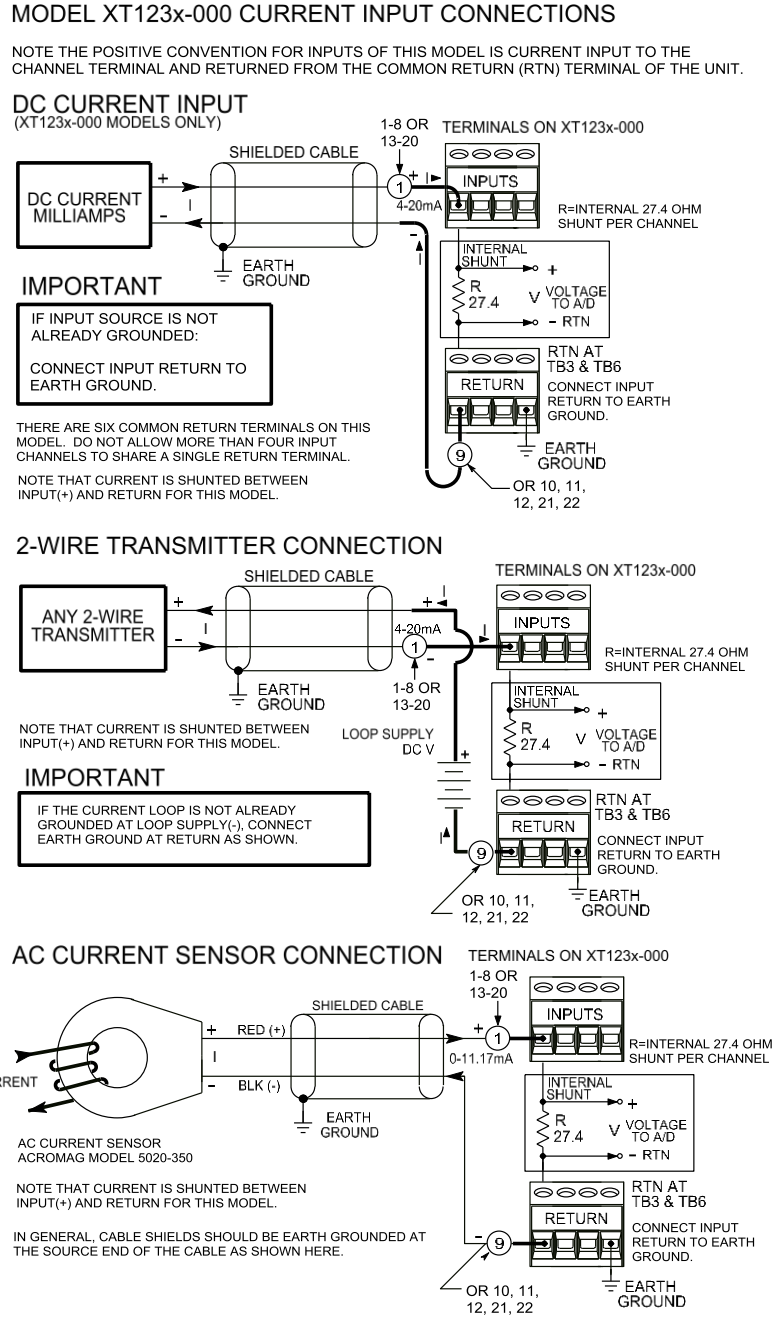
Input Connections

These models monitor DC current inputs and DC voltage inputs, in single-ended signal fashion (i.e. each input with respect to a common return connection). The XT1231-000 model has 16 Single-Ended DC current inputs, while the XT1241-000 model has 16 Single-Ended DC voltage inputs. An optional current sensor (Acromag model 5020-350) may be used with the XT1231-000 to additionally monitor AC currents. Observe proper polarity when making input connections. Refer to the following figures to wire the DC current (XT1231), or DC voltage (XT1241) inputs of these models.

Current Input Connections - Model XT1231-000

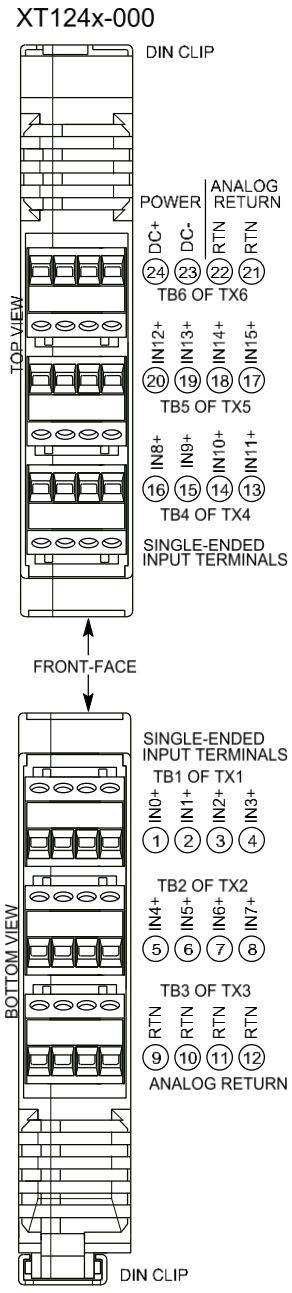
The **XT1231** model supports up to **16 Single-Ended DC current inputs**. The XT1231 shunts current to a common return through a 27.4Ω resistor, driving voltage through unity-gain buffers to a 16-bit A/D converter with a full-scale bipolar input range of ±1.325V. The ±20mA current shunted through a 27.4Ω resistor drives ±0.548V to the 16-bit A/D converter. The normal convention is that positive current is delivered to the channel positive terminal, and returned from the shared return terminal. Refer to the following figures for example DC current input connections to the XT1231-000 model.

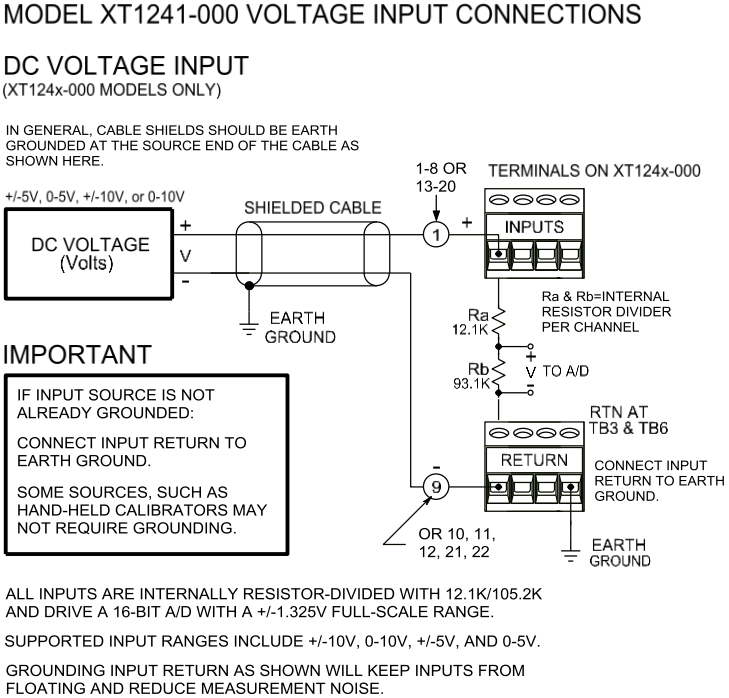



MODEL XT123x-000 CURRENT INPUT CONNECTIONS
NOTE THE POSITIVE CONVENTION FOR INPUTS OF THIS MODEL IS CURRENT INPUT TO THE CHANNEL TERMINAL AND RETURNED FROM THE COMMON RETURN (RTN) TERMINAL OF THE UNIT.
DC CURRENT INPUT
(XT123x-000 MODELS ONLY)
1-8 OR 13-20
TERMINALS ON XT123x-000
SHIELDED CABLE
DC CURRENT MILLIAMPS
INPUTS
4-20mA
R=INTERNAL 27.4 OHM SHUNT PER CHANNEL
INTERNAL SHUNT
R 27.4
VOLTAGE TO A/D
RTN
EARTH GROUND
IMPORTANT
IF INPUT SOURCE IS NOT ALREADY GROUNDED:
CONNECT INPUT RETURN TO EARTH GROUND.
RTN AT TB3 & TB6
RETURN
CONNECT INPUT RETURN TO EARTH GROUND.
THERE ARE SIX COMMON RETURN TERMINALS ON THIS MODEL. DO NOT ALLOW MORE THAN FOUR INPUT CHANNELS TO SHARE A SINGLE RETURN TERMINAL.
NOTE THAT CURRENT IS SHUNTED BETWEEN INPUT(+) AND RETURN FOR THIS MODEL.
OR 10, 11, 12, 21, 22
2-WIRE TRANSMITTER CONNECTION
SHIELDED CABLE
TERMINALS ON XT123x-000
ANY 2-WIRE TRANSMITTER
4-20mA
1-8 OR 13-20
R=INTERNAL 27.4 OHM SHUNT PER CHANNEL
EARTH GROUND
NOTE THAT CURRENT IS SHUNTED BETWEEN INPUT(+) AND RETURN FOR THIS MODEL.
LOOP SUPPLY DC V
IMPORTANT
IF THE CURRENT LOOP IS NOT ALREADY GROUNDED AT LOOP SUPPLY(-), CONNECT EARTH GROUND AT RETURN AS SHOWN.
AC CURRENT SENSOR CONNECTION
TERMINALS ON XT123x-000
1-8 OR 13-20
SHIELDED CABLE
RED (+)
BLK (-)
AC CURRENT
0-11.17mA
AC CURRENT SENSOR
ACROMAG MODEL 5020-350
NOTE THAT CURRENT IS SHUNTED BETWEEN INPUT(+) AND RETURN FOR THIS MODEL.
IN GENERAL, CABLE SHIELDS SHOULD BE EARTH GROUNDED AT THE SOURCE END OF THE CABLE AS SHOWN HERE.

Voltage Input Connections - Model XT1241-000

The **XT1241** model supports up to **16 Single-Ended DC voltage** inputs. You can select input ranges of ±10V, 0-10V, ±5V, or 0-5V. The XT1241 voltage is first divided-down with a 12.1K/105.2K resistive divider and drives unity-gain buffers to a 16-bit A/D converter with a nominal full-scale input range of ±1.325V (bipolar w/±32768). Connect your input voltage to input positive (+) and return (RTN) while observing proper polarity. If the input signal source is floating (not earth grounded), then it is recommended that you also connect one input return terminal to earth ground as shown below. Refer to the following figures for example DC voltage input connections.



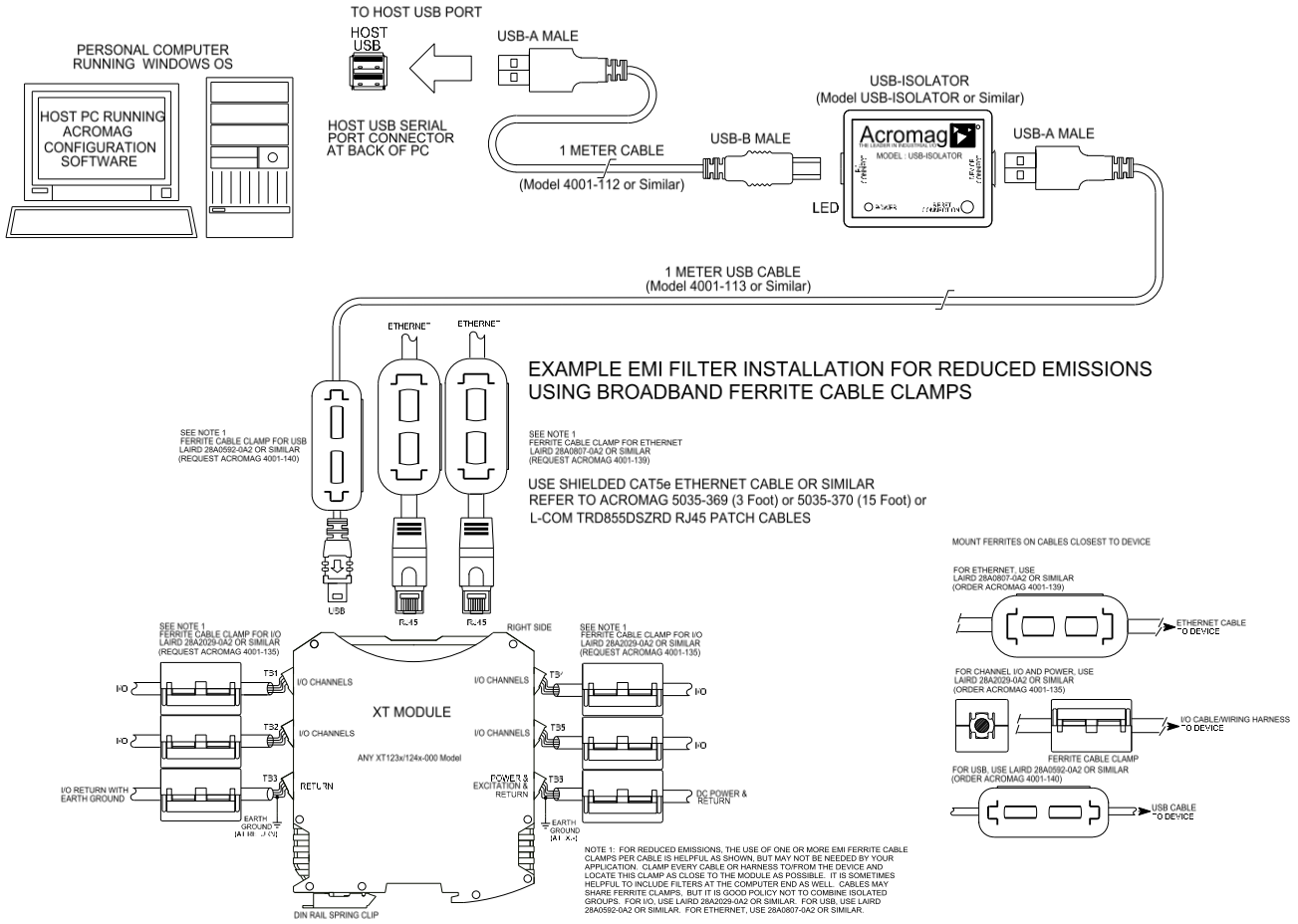

MODEL XT1241-000 VOLTAGE INPUT CONNECTIONS
DC VOLTAGE INPUT
(XT124x-000 MODELS ONLY)
IN GENERAL, CABLE SHIELDS SHOULD BE EARTH GROUNDED AT THE SOURCE END OF THE CABLE AS SHOWN HERE.
+/-5V, 0-5V, +/-10V, or 0-10V
DC VOLTAGE (Volts)
+
V
-
SHIELDED CABLE
EARTH GROUND
1-8 OR 13-20
TERMINALS ON XT124x-000
+
INPUTS
Ra
12.1K
Rb
93.1K
Ra & Rb=INTERNAL RESISTOR DIVIDER PER CHANNEL
+
V
-
TO A/D
RTN AT TB3 & TB6
RETURN
-
9
CONNECT INPUT RETURN TO EARTH GROUND.
OR 10, 11, 12, 21, 22
EARTH GROUND
IMPORTANT
IF INPUT SOURCE IS NOT ALREADY GROUNDED:
CONNECT INPUT RETURN TO EARTH GROUND.
SOME SOURCES, SUCH AS HAND-HELD CALIBRATORS MAY NOT REQUIRE GROUNDING.
ALL INPUTS ARE INTERNALLY RESISTOR-DIVIDED WITH 12.1K/105.2K AND DRIVE A 16-BIT A/D WITH A +/-1.325V FULL-SCALE RANGE.
SUPPORTED INPUT RANGES INCLUDE +/-10V, 0-10V, +/-5V, AND 0-5V.
GROUNDING INPUT RETURN AS SHOWN WILL KEEP INPUTS FROM FLOATING AND REDUCE MEASUREMENT NOISE.

Analog Return Ground Connection

The connection diagrams provided show proper ground connection with input Return earth grounded and this is important for the inputs of this model. If your input measurement is over-range clamped, appears noisy, or unstable, please review your grounding practices. Note this module includes six common input return terminals (RTN) shared between 16 input channels. You only need to earth ground one of these terminals to ground the input circuit, as they are all connected in common.

EMI Filter Installation

For low CE-rated radiated emissions, the use of one or two split/snap-on ferrite cores on all cables or harnesses to/from the device as shown in the drawing on the next page is helpful. These are also helpful for cables connected to Host USB and Ethernet as well. Use Laird 28A2029-0A2 or similar for I/O & Power (Acromag 4001-135), Laird 28A0807-0A2 or similar for Ethernet (Acromag 4001-139), and Laird 28A0350-0B2 or similar for USB cables (Acromag 4001-140). Locate this ferrite by clamping it outside of all I/O cables or wiring harnesses to/from the module (USB, Ethernet, output group, DC power), and as close to the module as possible. While the use of these ferrites is helpful to obtain low CE-rated emissions, it may not be required for your application. Note also that individual cables may share a ferrite, but it is not good practice to combine isolated circuits inside the same ferrite, but rather separate isolated circuits for safety and greater noise immunity.


TO HOST USB PORT
HOST USB
USB-A MALE
PERSONAL COMPUTER RUNNING WINDOWS OS
HOST PC RUNNING ACROMAG CONFIGURATION SOFTWARE
HOST USB SERIAL PORT CONNECTOR AT BACK OF PC
1 METER CABLE
(Model 4001-112 or Similar)
USB-B MALE
USB-ISOLATOR
(Model USB-ISOLATOR or Similar)
Acromag
MODEL : USB-ISOLATOR
LED
USB-A MALE
1 METER USB CABLE
(Model 4001-113 or Similar)
ETHERNET
ETHERNET
EXAMPLE EMI FILTER INSTALLATION FOR REDUCED EMISSIONS
USING BROADBAND FERRITE CABLE CLAMPS
SEE NOTE 1
FERRITE CABLE CLAMP FOR USB
LAIRD 28A0592-0A2 OR SIMILAR
(REQUEST ACROMAG 4001-140)
SEE NOTE 1
FERRITE CABLE CLAMP FOR ETHERNET
LAIRD 28A0807-0A2 OR SIMILAR
(REQUEST ACROMAG 4001-139)
USE SHIELDED CAT5e ETHERNET CABLE OR SIMILAR
REFER TO ACROMAG 5035-369 (3 Foot) or 5035-370 (15 Foot) or
L-COM TRD855DSZRD RJ45 PATCH CABLES
USB
RJ-45
RJ-45
SEE NOTE 1
FERRITE CABLE CLAMP FOR I/O
LAIRD 28A2029-0A2 OR SIMILAR
(REQUEST ACROMAG 4001-135)
RIGHT SIDE
SEE NOTE 1
FERRITE CABLE CLAMP FOR I/O
LAIRD 28A2029-0A2 OR SIMILAR
(REQUEST ACROMAG 4001-135)
I/O
I/O
I/O RETURN WITH EARTH GROUND
T31
T32
T33
I/O CHANNELS
I/O CHANNELS
RETURN
XT MODULE
ANY XT123x/124x-000 Model
I/O CHANNELS
I/O CHANNELS
POWER & EXCITATION & RETURN
T34
T35
T36
I/O
I/O
DC POWER & RETURN
EARTH GROUND
EARTH GROUND
DIN RAIL SPRING CLIP
NOTE 1: FOR REDUCED EMISSIONS, THE USE OF ONE OR MORE EMI FERRITE CABLE CLAMPS PER CABLE IS HELPFUL AS SHOWN, BUT MAY NOT BE NEEDED BY YOUR APPLICATION. CLAMP EVERY CABLE OR HARNESS TO/FROM THE DEVICE AND LOCATE THIS CLAMP AS CLOSE TO THE MODULE AS POSSIBLE. IT IS SOMETIMES HELPFUL TO INCLUDE FILTERS AT THE COMPUTER END AS WELL. CABLES MAY SHARE FERRITE CLAMPS, BUT IT IS GOOD POLICY NOT TO COMBINE ISOLATED GROUPS. FOR I/O, USE LAIRD 28A2029-0A2 OR SIMILAR. FOR USB, USE LAIRD 28A0592-0A2 OR SIMILAR. FOR ETHERNET, USE 28A0807-0A2 OR SIMILAR.
MOUNT FERRITES ON CABLES CLOSEST TO DEVICE
FOR ETHERNET, USE
LAIRD 28A0807-0A2 OR SIMILAR
(ORDER ACROMAG 4001-139)
ETHERNET CABLE TO DEVICE
FOR CHANNEL I/O AND POWER, USE
LAIRD 28A2029-0A2 OR SIMILAR
(ORDER ACROMAG 4001-135)
I/O CABLE/WIRING HARNESS TO DEVICE
FERRITE CABLE CLAMP
FOR USB, USE LAIRD 28A0592-0A2 OR SIMILAR
(ORDER ACROMAG 4001-140)
USB CABLE TO DEVICE

Earth Ground Connections

The unit housing is plastic and does not require an earth ground connection itself. If the module is mounted in a metal housing, an earth ground wire connection to the metal housing's ground terminal (green screw) is usually required using suitable wire per applicable codes. Circuits wired to power, I/O, and the network should be earth grounded as reflected in the connection diagrams. In general, at least one input return terminal (RTN) should be earth grounded, and earth ground should also be included at the DC minus terminal of the power supply. These ground connections are recommended for best results and help protect the unit by giving it a low impedance path to ground for shunting destructive transient energy. See the Electrical Connections Drawings for input, power, and network ground connections.

Note: A USB isolator is recommended when connected to a grounded Personal Computer for configuration purposes. This will avoid a potential ground loop that can occur if your input signal is already earth grounded, as a PC commonly earth grounds its USB port and this makes contact with both the USB signal and shield ground, which this module holds in common to its input circuit return.

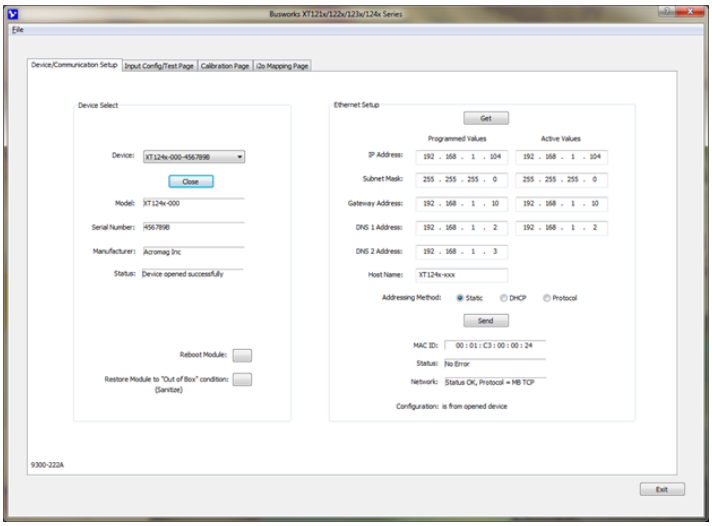
CONFIGURATION SOFTWARE

Get the USB Configuration Software for Your Model

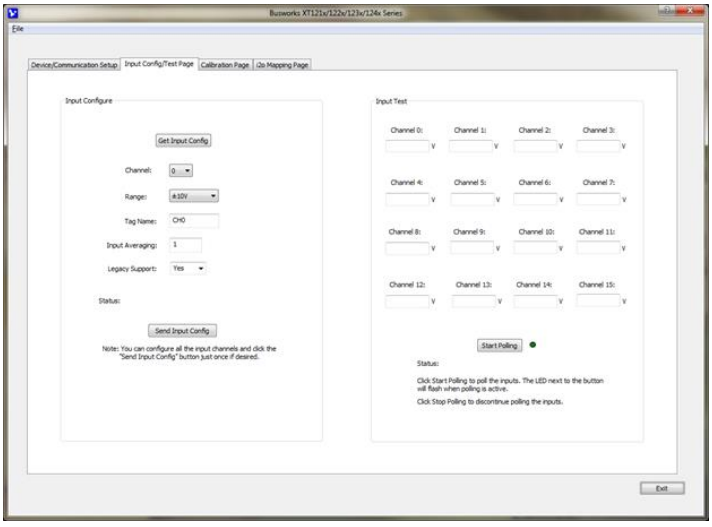
While this is an Ethernet network input module, it can only be configured and calibrated via its Configuration Software over a USB connection to a Windows-based PC or laptop. USB saves you the trouble of having to already know its IP address setting, or having to change the address setting of your network interface card to an address within its address domain in order to communicate with it. USB software is contained in a zip file that can be downloaded free of charge from our web site at www.acromag.com. Look for the software zip file 9500465A.zip (XT install shield shell program) in the Documents and Downloads page for your XT product. Initially, you will have to answer a few questions to open a user account and download this file to your computer. This zip file will extract to a model-specific executable file XT12xxConfig.exe, which installs in an Acromag subdirectory off the Program Files directory of your PC. The software is compatible with XP or later versions of the Windows operating system. Note that you must have administrator rights to download and install this software onto your PC or laptop. Once you have installed the software, be sure to navigate to the *Program Files\Acromag* subdirectory and select the correct *modelconfig.exe* software for your particular module family. This same software is also included on a CDROM bundled with the Configuration Kit XT-SIP (see Accessories), but downloading it from the web will help to ensure that your copy is the most up to date available. The particular *model*Config.exe software for this unit supports eleven other model variations—six models with 8 differential current or voltage inputs, plus six models with 16 single-ended current or voltage inputs.

Configuration Software…

After booting the Configuration software for this model, the initial Device/Communication Setup page will appear. This screen is used to selectively connect to units over USB and to configure the Ethernet parameters necessary to communicate with them over the network. Once you select a device and click **[Open]** to connect to an XT1231-000 or XT1241-00 model, your screen will look similar to the following:



If you click on the I/O Config/Test Page tab, the following screen will appear:



For a more detailed configuration procedure, see Configuration Step-by-Step of the Technical Reference on page 16.

Device Select (First Connect to the Unit Here)

- Select from connected modules and Open communication with them.
- Display the Model, Serial Number, and Manufacturer of the connected module and report the status of the connection.
- Reboot a module to force a system reset to the power-up state.
- Restore a module to its initial programmed “out-of-box” state.

Ethernet Setup (Setup your Network Parameters)

- Retrieve the connected modules current network configuration with the **[Get]** function.
- Set the Network IP address required for Ethernet communication on your network.
- Set the subnet mask, gateway, and/or domain name server addresses for your network.
- **[Send]** your parameters to the connected unit and read back the USB communication status.

There are three other screens that can be selected by clicking their tabs, I/O Config/Test, and i2o Mapping. A short description of the controls of the Device/Communication Setup page follows:

I/O Configure (Channel-by-Channel)

- Retrieve the connected module’s current channel configuration with **[Get Input Config]**.
- Set the channel 0-15 to address and choose an input range.
- Apply a tag name to the input channel for reference purposes over USB (up to 8 characters).
- Set input averaging from 1-200 samples.
- Set Legacy Support to “No” for bipolar/unipolar input normalization to ±30000/0-30000, or “Yes” for ±20000/0-20000.
- Send your channel configuration to the connected unit.

Input Test

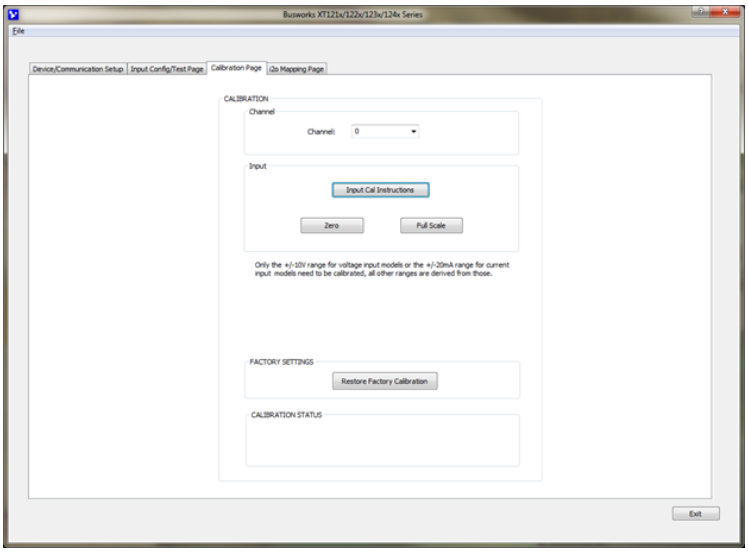
After making I/O configuration changes, you can use the I/O Test controls to verify operation of your inputs.

- Start/Stop polling the input channels.
- Display the current reading of the inputs.

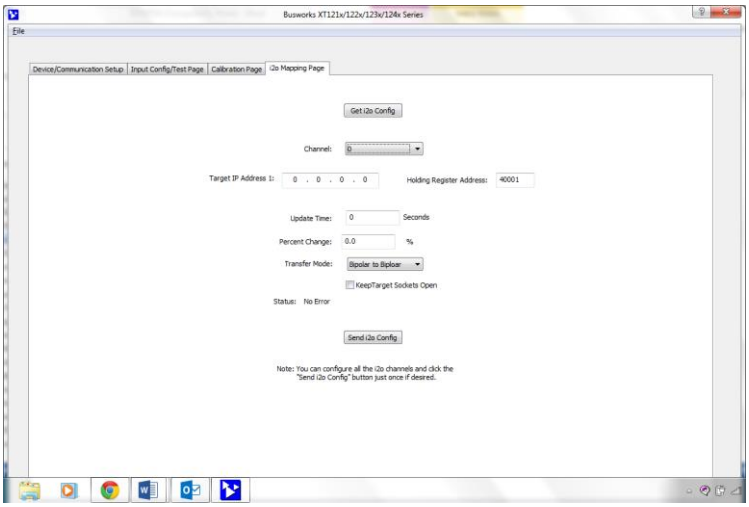
Quick Overview…

Once you've configured your unit and optionally your i2o parameters, you are ready to install it in the field, as the unit has already been factory calibrated.

If you click on the Calibration Page tab, the following screen will appear:



If you click the i2o Mapping tab, the following screen will appear:



HELP – You can press F1 for Help on a selected or highlighted field or control. You can also click the [?] button in the upper-right hand corner of the screen and then click to point to a field or control to get a Help message pertaining to the item you pointed to.

For a more detailed configuration procedure, see Configuration Step-by-Step of the Technical Reference on page 16.

Calibration

If you encounter an error that is out of specification, you can click the **Calibration Page** tab to display the Calibration control page as shown at left.

IMPORTANT: This unit has already had its input channels factory calibrated with high precision. Attempts to recalibrate the input channels could degrade their performance if not done properly, or done using lower grade equipment. Consider your decision to recalibrate carefully.

Set the Input Range to calibrate from the "I/O Config/Test" page. Then select your channel to calibrate here and initiate calibration by clicking **[Input Cal Instructions]** and following the on-screen prompts.

- Click Input **[Zero]** and you will be prompted to precisely input the min value of your selected input range at the input channel, then click the **[OK]** button and follow the prompts.
- Click Input **[Full-Scale]** and you will be prompted to input the full-scale value of your selected input range at the channel, then click the **[OK]** button and follow the prompts.
- Use **[Restore Factory Calibration]** to restore the module's original factory calibration.

i2o Mapping

This model includes a special remote messaging function called i2o, for input-to-output communication. This allows it to send its input information over the network, to outputs on a compatible unit, without having to hard-wire an I/O connection. The i2o Mapping Page shown at left is used to setup this feature by specifying the static IP address of the target output module to send this input channel data to, either upon percent change, or cyclically at the update time specified.

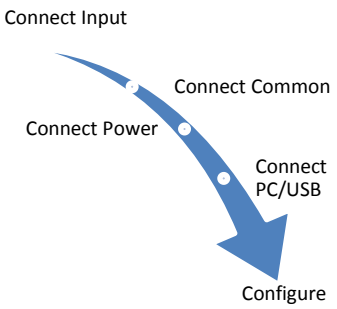
- Set the IP address of one or two target devices to send input data to their output channels.
- Specify to send data upon percent change, or cyclically per an update time that you specify.
- Retrieve the current i2o configuration from the connected module, or send a new configuration to the connected module.

TECHNICAL REFERENCE

CONFIGURATION STEP-BY-STEP

Getting Connected

This section will walk you through the Connection-Configuration process step-by-step. But before you attempt to reconfigure this module, please make the following electrical connections.



1. **Connect Inputs:** Refer to Input Connections at the front of this manual and connect your input(s) as required for your application. Inputs of this model are single-ended and share a common return. Do not allow inputs to float (see #2 below).

2. **Connect Analog Common:** If your input signal is not already grounded, you should connect earth ground to analog input return (to RTN at one point). Doing this will keep the inputs from floating and within the common mode range of the analog to digital converter of this model. Failure to ground your input return could increase measurement noise. Earth ground applied here also allows the input filters to shunt potentially harmful transient energy to ground via a low impedance path to ground, helping to protect the input circuit from transient damage.

3. **Connect Power:** You need to connect power from 12-32V to power this module. Current required will vary with voltage level (refer to Specifications). Your supply must be capable of providing at least twice the maximum rated current for your voltage level. You can choose to connect to Power via terminals on the unit, or via optional terminals that connect to the module's bus connector along the DIN rail (See Power Connections). Supplies capable of delivering greater than 2.5A should be fused with a surge-tolerant slow-blow fuse.

4. **Connect to PC via USB:** Refer to USB Connections of page 9 and connect the module to your PC or laptop using the USB isolator and cables provided in Configuration Kit XT-SIP.

   Now that you have made your connections and applied power, you can execute the XT12XXConfig.exe software to begin configuration of your unit (software is compatible with XP or later versions of the Windows operating system). Note that this same software is used for twelve different models, including 3 different models of XT123x-000 with 16 single-ended current inputs, and 3 different models of XT124x-000 with 16 single-ended voltage inputs.

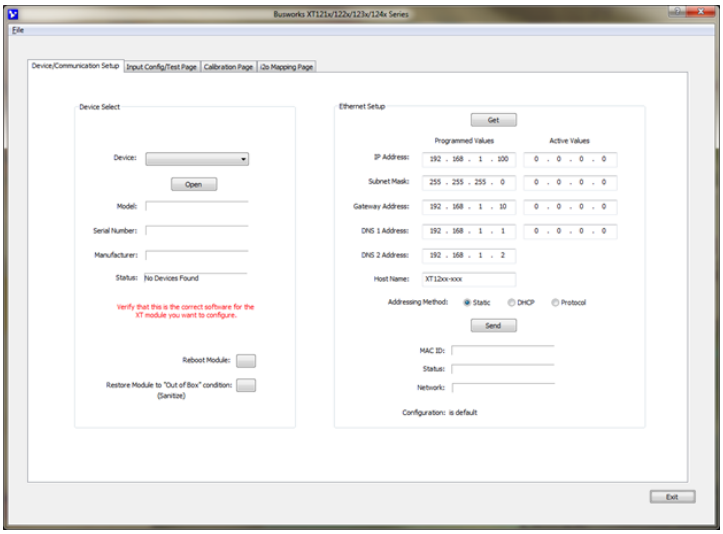
   IMPORTANT: Allow the unit to fully power-up and establish its Ethernet connection before attempting to open USB communications with the unit using the XT12xxconfig.exe software (wait ~30 seconds after powering-it up to give it time to initialize).

Note that you do not connect your module to an Ethernet network in order to configure it. It is configured for network operation by initially connecting to USB with a host PC running model-specific configuration software. This has the advantage of not having to know the module's IP address setting, or having to change the address setting of your network card to an address in the module's subnet address domain in order to talk to it.

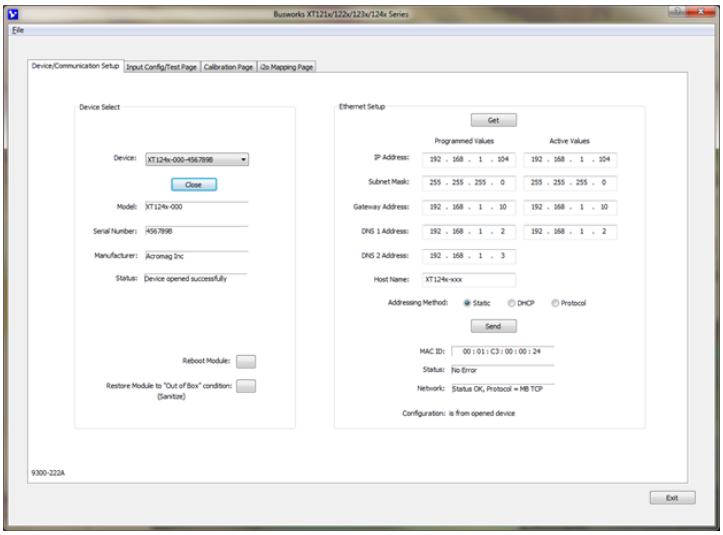
Device/Communication Setup

Note that you should already have power connected to the XT123/XT124 at this point, as this model does not utilize USB power and you will not be able to configure, calibrate, or test the unit without also having power applied.

After executing the Acromag Configuration software for this model, the screen shown below will appear, if you have not already connected to your transmitter via USB (note the Device Select fields are blank under these conditions).



Once you have selected a device, click the **[Open]** button to open communication with the unit and the screen will fill out the connected module's information similar to below (the selected unit's Model, Serial Number, Manufacturer, and a USB connection status message will be displayed).



The Device/Communication Setup screen is split into 2 parts: Device Select & Ethernet Setup as follows:

Device Select

Connect your PC to the unit via USB, and the unit's model-serial information will appear in the Device field as shown in the second screen at left. If you happen to be connected to more than one unit via a USB hub, you can use the Device scroll field to select another unit, using the serial information suffix of the Device Model number to discern one unit from another.

Once you have selected a device, click the **[Open]** button to open communication with the unit.

After clicking [Open], the selected unit's Model, Serial, Manufacturer, and a connection status message will be displayed as shown in the second screen at left. The i2o Mapping Page tab also disappears, as i2o is not available for Ethernet/IP models.

TIP: Always Close a connection with one device before selecting another device.

You can use the **[Reboot Module]** button to force a reset of the unit by clicking on it, an effect equivalent to a power-on reset.

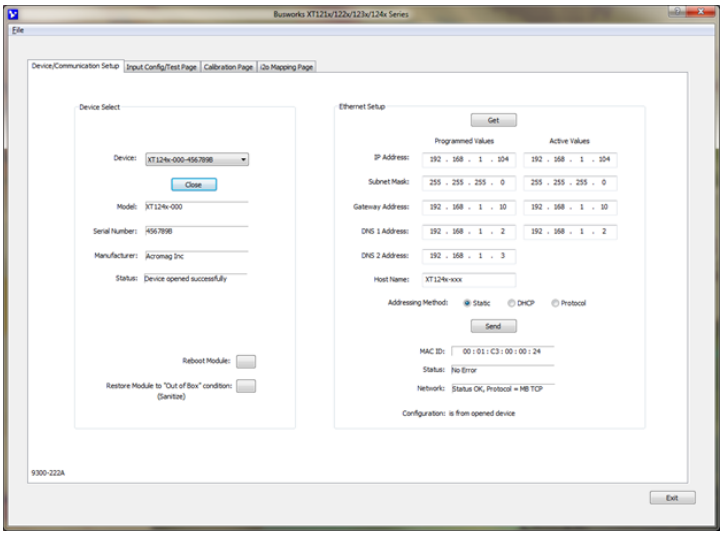
You can use the **[Restore Module]** button to restore a module to its initial "out-of-box" configuration.

Ethernet Setup

Use the **[Get]** button to retrieve the current Ethernet setup of the connected module (sometimes the Active Values fields will indicate zero's and you must click [Get] to retrieve the actual active values).

Use the Ethernet Setup portion of the Device/ Communication Setup screen shown at left to specify network parameters required to communicate with this module (host) over Ethernet. By connecting USB to set these parameters, you do not have to change your PC or network adapter's IP address in order to address the unit, simplifying communication setup (you may still have to consult with your network administrator to complete this page). The functionality of these parameters is defined below:

Device/Communication Setup…



The Internet or world-wide web is actually a large network made up of many smaller networks (sub-networks) linked together by gateways or routers. The gateway or router serves as an access point to/from a particular sub-network. For example, your ISP provides DSL modems or cable modems which connect your local hardware to the Internet and often serve as gateways. The gateway address is the address of this gateway or router in the same subnet as the host, and is used as the bridge to connect to various other sub-networks with different sub-network addresses and address masks, that collectively connect together to make up the Internet. Data packets sent over the Internet contain both the sender's Internet address and the receiver's address. A packet is first sent to a gateway computer that understands its own domain or group of host addresses. The gateway reads the destination address of the packet, and if it is outside of its own domain, it forwards the packet on to an adjacent gateway that again reads the destination address. Then that gateway will forward the message on, if the address is not within its domain. Eventually, one gateway recognizes the packet as belonging to a host within its domain. Finding a match, that gateway forwards the packet directly to the host whose address is specified. Rather than continually passing a packet from gateway to gateway, some networks will use a default gateway which is the address of another node on the same network that the software uses when an IP address does not match any other routes in the routing table (address domain) of the primary gateway.

Ethernet Setup…continued

An **IP Address** (Internet Protocol Address) is an identification number for any host (this module) on any TCP/IP network (including the internet) and uniquely defines one host from all other computers (hosts) on the Internet. The IP address is made up of four octets (8 bits), each octet having a value between 0-255 (00H-FFH). It is expressed here in decimal form, with a period between octets.

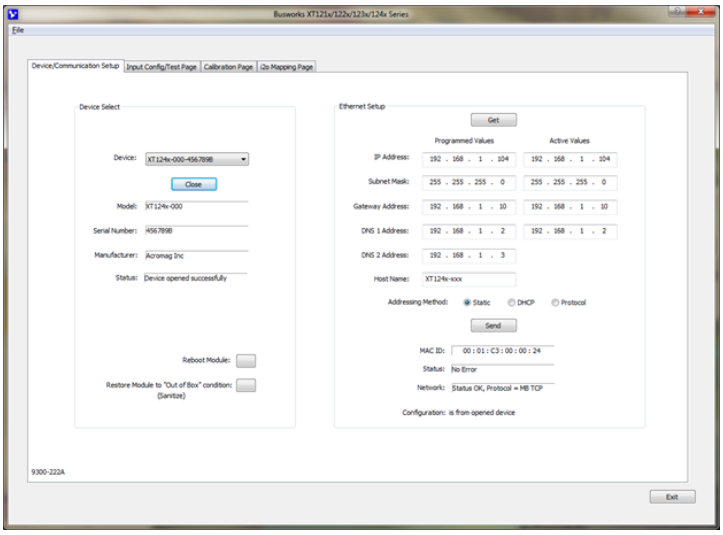
The **Subnet Mask** is used to subdivide the host portion of the IP address into two or more subnets. The subnet mask will flag the bits of the IP address that belong to the network address, and the remaining bits that correspond to the host/node portion of the address. The unique subnet to which an IP address refers to is recovered by performing a bitwise AND operation between the IP address and the mask itself, the result being the subnet address.

Gateway Address refers to the IP Address of the gateway this module is to cross, if your local area network happens to be isolated or segmented by a gateway. Typically, it is assigned the first host address in the subnet address space. If a gateway is not present, then this field should contain an unused address within the host subnet address range.

NOTE: Fortunately, this model uses USB to setup its network configuration parameters, allowing you to instead change its IP address to an address compatible with your own PC network without having to network connect to it first. This saves you from having to consult with your network administrator to either temporarily change your PC's TCP/IP configuration (see TCP/IP Properties of Network Configuration in Windows), or perhaps having to create a separate private network using a second network adapter installed in your PC. The necessary steps would vary with your operating system, but can get quite involved.

A DNS server relates symbolic names to actual numeric IP addresses, while the DHCP server is responsible for dynamically passing out IP addresses. The **DNS 1 Address** refers to the IP address of the first Domain Name Server used on this network. The **DNS 2 Address** refers to the IP address of the secondary Domain Name Server used on this network.

Device/Communication Setup…



You can click the **[Exit]** button in the lower right hand part of this screen to exit the Configuration Software, or simply click on another tab to access another page before exiting this software.

Ethernet Setup…continued

The **Host Name** is the name to be assigned to this host (this module on the network), if its address happens to be assigned dynamically using DHCP.

The **Addressing Method** refers to how this network module will obtain its IP address when connected to its network.

Static addressing is as the name implies—*static*, and represents a unique fixed IP Address generally assigned by your service provider or system administrator. The default address assigned to this module is 192.168.1.100 and static (refer to product side label).

DHCP (Dynamic Host Configuration Protocol) refers to a protocol for assigning dynamic IP addresses to devices on a network. With dynamic addressing, a device can have a different IP address every time it connects to the network. In some systems, it can even change while it is still connected.

The Protocol addressing method refers to allowing the particular application protocol specific to this model to set the IP address. This optional selection only applies to Ethernet/IP & Profinet models (required). In this method, the TCP/IP object of the particular protocol (for Ethernet/IP) sets the address. Profinet requires protocol addressing and has its own method for accomplishing address assignment via this method.

By default, the module is setup to use **Static IP Addressing and a default Static IP Address of 192.168.1.100**. You can optionally choose to have the IP address assigned dynamically via DHCP, but this will additionally require that you specify a valid Host Name to retrieve the address from. Choosing Protocol gives the application protocol permission to assign the address and is required for Profinet models.

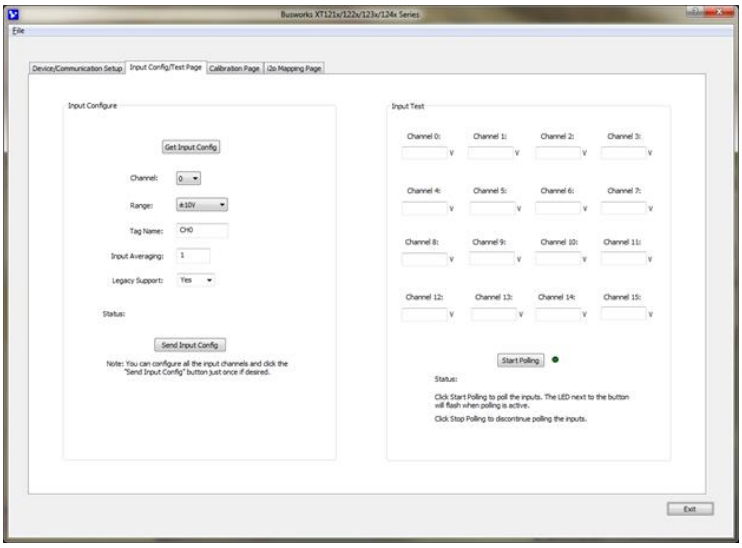
You can click the **[Send]** button to write your Ethernet Setup parameters to the unit once you are done making your selections. This completes any changes made on this page.

The Status field will indicate the status of your sent parameters over USB after clicking [Send]. The Network field will indicate the current network connection status, as well as the protocol used for this network. The Configuration field will indicate whether the viewed configuration is from an open device, or a default configuration.

You can click the **[Exit]** button in the lower right hand part of this screen to exit the Configuration Software, or simply click on another tab to access another page before exiting this software.

I/O Configuration/Test

You can click the **"I/O Config/Test Page"** page tab to begin configuring the unit, and/or optionally test its operation. The I/O Config/Test screen for this model is shown below:



I/O Configure

If you are connected to a module, the initial I/O Config/Test screen represents the current configuration before making changes.

Get the Input Configuration…
If you have loaded the configuration from a saved file, or have made changes to any fields on this page, you can always click the **[Get Input Config]** button at the top of the screen to retrieve the connected module's current channel configuration (all channels). Otherwise, the connected module's current configuration was loaded automatically when you selected the tab for this page.

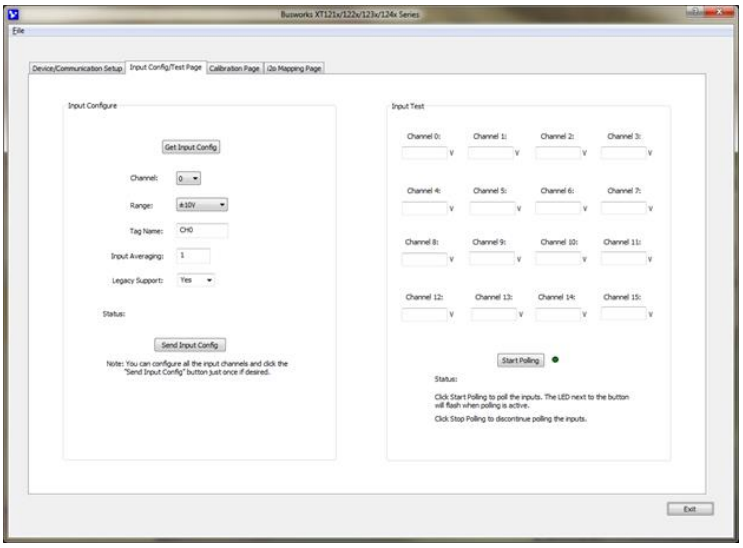
Note that if you make any changes to the selections indicated, the only way to preserve your changes is to write them to the device by clicking **[Send Input Config]** after completing your selections, or to save them to a file by clicking **"File"** in the upper left-hand corner of the screen.

Select the Channel…
This software supports models having 8 and 16 channels, channels 0-7, and/or 0-15, according to the model. This model has 16 Single-Ended input channels and you can use this software to configure each channel individually. You could choose to configure the channel's selectively, then click **[Send Input Config]** to write the channel configuration to the unit, or more simply make changes to many channels and click **[Send Input Config]** one time to write all the channel configurations to the unit at once.

Select the Range…
Use the "Range" field to select your input range. For the XT1232-000 model, you can select DC current ranges of ±20mA, 0-20mA, 4-20mA, and 0-11.17mA. For the XT1242-000 model, you can select DC voltage ranges of ±10V, ±5V, 0-10V, and 0-5V. Internally, the 16-bit A/D has a fixed range of ±1.325V (±32768).

Set a Tag Name (Optional, up to 8 Characters)….
You can give this input channel a name to document its purpose if desired. This is not used by the firmware or software and just serves as a convenient label for discerning the input function or its application over USB.

I/O Configuration/Test…



HELP – You can press **[F1]** for Help on a selected or highlighted field or control. You can also click the **[?]** button in the upper-right hand corner of the screen and click to point to a field or control to get a Help message pertaining to the item you pointed to.

Set Input Averaging…
(This is a Global Setting, Not Per Channel):

Use this field to set the integer number of input samples to average over before updating the input values/readings. Set this number from 1 to 200. Note that higher averaging levels result in lower average noise, but with slower I/O response times. Selecting 1 designates that no averaging will be performed.

Status…

This field displays status messages relative to sending and receiving configuration parameters to/from the module via USB.

Send Input Configuration and Read Status…

Once you've made your configuration selections, click **[Send Input Config]** to write them to the module. Do this one time after setting up all input channels individually. You can read the USB status of your sent message to the unit in the "Status" field just above this button. Alternately, you could click **"File"** in the upper left hand corner of the screen to save the settings you made to a file on your PC, for reference later.

Input Test

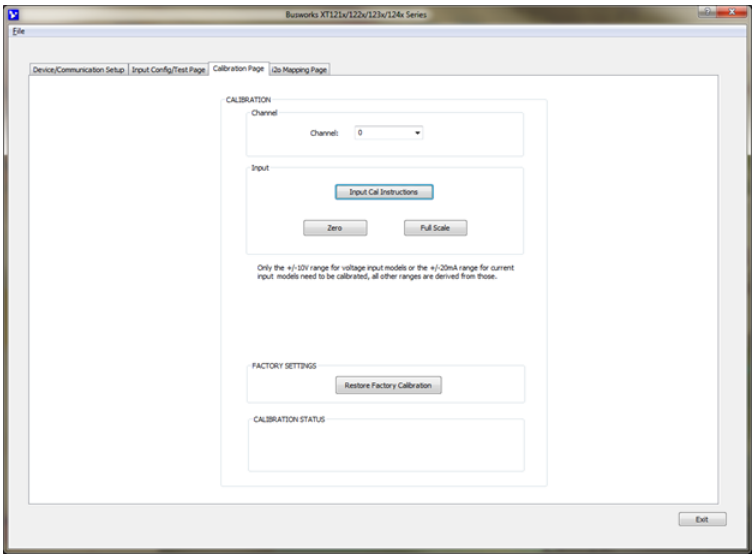
At this point, you can test the module's operation by clicking on the **[Start Polling]** button of the I/O Test section on the I/O Config/Test page to trigger the software to periodically read the inputs (updates about once per second) and display their values in the fields below their channel designators. Note the simulated lamp next to the button flashes slowly each time it samples the input. Click **[Stop Polling]** to stop polling the inputs before moving onto the next page.

Start Polling Button (Toggle Start/Stop): Click this button to Start/Stop periodic polling of the input channels. The channel value is indicated and updated about once per second.

TIP: Be sure to Stop polling a module before moving onto another page. Note that you will always have to restart polling if you come back to this page and want to poll the inputs.

Calibration Page

Once you've configured your unit and optionally your i2o parameters, you are ready to install it in the field, as the unit has already been factory calibrated. If you later encounter error that is out of specification, you can choose to click the **Calibration Page** tab to display the Calibration control page shown below:



CAUTION-Input Calibration: Driving input levels outside of the nominal input range of the unit will not be acceptable for calibration of zero or full-scale. Since input levels cannot be validated by the software during field calibration, driving incorrect signal levels to the unit will produce an undesired output response.

IMPORTANT: This unit has already had its input channels factory calibrated with a high level of precision. Attempts to recalibrate the input channels could degrade their performance if not done properly, or done using lower grade equipment. Consider your decision to recalibrate carefully.

Calibration of this model is a simple process initiated by clicking the **[Input Cal Instructions]** button to begin, then following the on-screen prompts. Note that the current and voltage ranges of these models are sub-ranges of ±20mA (XT123x) and ±10V (XT124x), and are indirectly calibrated by calibrating ±20mA or ±10V.

CALIBRATION – Input

*Before attempting to recalibrate an input channel, first set the Input Range to calibrate from the "I/O Config/Test" page. Additionally, make sure you write your range selection to the unit by clicking the **[Send Input Config]** button of that page.*

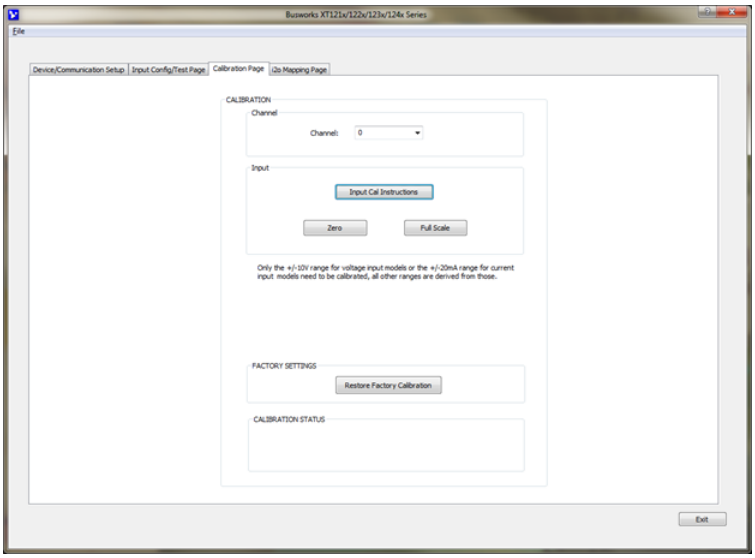
Use the Calibration Channel scroll field to select the particular channel to calibrate. This model has sixteen single-ended input channels numbered 0 to 15 (i.e. 16 channels measure their input with respect to a common grounded return).

After setting your input parameters, and selecting a channel to calibrate on the I/O Config/Test Page, click the **[Input Cal Instructions]** button to begin input calibration and enable the Input **[Zero]** and **[Full-Scale]** buttons of the Calibration Page.

Click the Input **[Zero]** button and you will be prompted to input the minimum value of your selected input range at the input channel. If you have a voltage input model, this will be 0, -5V or -10V. Current input models may choose -20mA, 0mA, or 4mA. Once you input zero precisely, click the **[OK]** button and follow the on-screen prompts to complete zero calibration.

Click the Input **[Full-Scale]** button and you will be prompted to input the full-scale value of your selected input range at the channel. For voltage models, this will be 5V or 10V, depending on the input range. For current input models, this will be 11.17mA or 20mA, depending on the input range. Once you input full-scale precisely, click the **[OK]** button and follow the on-screen prompts to complete full-scale calibration.

Factory Settings



You can use the FACTORY SETTINGS **[Restore Factory Calibration]** button of this page to restore the module's original factory calibration if you think you made an error during recalibration, degraded its performance, or the input reading appears erratic.

In addition to the Restore Factory Calibration function of this page, you could optionally use the **[Restore to "Out of Box" Condition]** button of the Device/Communication Setup Page to return the unit to its original factory configuration settings. This other function does not restore calibration, but only configuration. Alternatively, that button can be used as a sanitation tool to restore a unit to its initial configuration when decommissioning it.

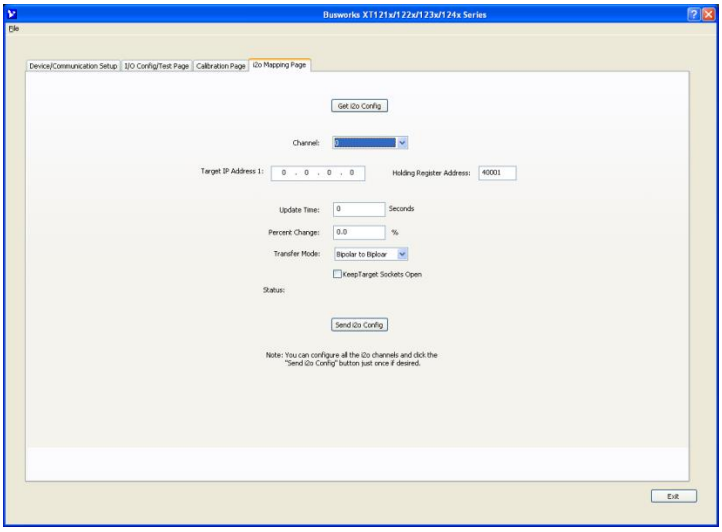
CALIBRATION STATUS

This field displays calibration status messages relative to USB like "No Error", "Transfer Error", and "Timeout Error" during calibration. If you encounter a Transfer or Timeout Error, you may have to repeat the calibration process. Additionally, it may be necessary to reboot this software.

I2o Mapping Page

This model supports a special remote messaging feature called i2o, for input-to-output communication. This capability allows it to send its analog input information over the network to the analog outputs of compatible units (i.e. XT1531, XT1541, etc.). The i2o Mapping Page shown below is used to setup i2o at the input module, on a channel-by-channel basis, by specifying the IP address of the target (output module), plus the output holding register address (specific channel), to send the input channel data to.

Click the "i2o Mapping Page" tab of the Configuration Software and the screen below will be displayed:



IMPORTANT: i2o refers to an Acromag proprietary method of input-to-output communication, done over the network, without other hard-wired connections between inputs and outputs. This is not a Modbus TCP/IP function and the i2o mapping feature of this model may only be configured via this software. As such, there are no Modbus registers for specifying i2o parameters. Under normal operation, this module is designed to function as a Modbus TCP/IP slave/server. By the Modbus standard, Modbus servers are not allowed to initiate messages on their own and may only respond to client/master requests. Thus, the i2o functionality of this unit is a special application that may cause confusion for some other master/client devices linked to the same network. In any case, other master devices on a network should be restricted from attempting to control i2o target output devices on the same network to avoid contention.

With i2o, a client-server network connection is established between a sending-module (client) and a target output module (server). This connection refers to an established data path, or socket, between the client input device and server output—it does not refer to just the physical network connection between devices. It is similar to other client-server network connections that are created for the exchange of data between devices, such as that between a Modbus Master and slave, or that between a networked PLC, HMI, or other client device and its target server device.

This model has 16 single-ended input channels numbered 0-15 and each of 16 input channels may be separately mapped to any analog output channel on any compatible output module. Use this page to select an input channel, specify an IP address of a target output module and its specific Holding Register Address. You may choose to send the i2o message cyclically, according to the specified Update time, and/or after a certain percent of span change in the input measurement. You can even set the transfer mode for bipolar/unipolar conversions between different range types. You can also choose to maintain an i2o connection by enabling Keep Sockets Open, or to open and close the connection for each i2o message.

i2o messaging works best if target output module(s) are already online and ready to receive messages. It still works if the target output module comes online after the input module, but may take several minutes to "discover" the network targets and begin transmitting to them. If this input module or the target module(s) go offline, remote i2o messaging will resume on its own when the connection is re-established, but "healing" may take several minutes depending on which device(s) went offline, why, and for how long.

i2o Mapping Page…

The i2o function sends normalized analog input channel data of this unit cyclically according to an update time, and/or upon exceeding a specified percent change in value, to any analog output channel of a compatible analog output device by specifying its IP address and its output channel register address. It is not recommended to set an update time greater than 99 seconds and also choose "Keep Target Sockets Open", as increasing bandwidth and shortening response times by keeping the sockets open is not a concern when cyclical messages are spaced farther than 99 seconds apart. Still, you should be conservative when setting an update time—shorter intervals than needed may unnecessarily increase network traffic while longer intervals will conserve network bandwidth. If Keep Socket Open is disabled, then you should specify an i2o Update Time at the client that is less than the watchdog time of the server, to ensure that the server's output watchdog does not time-out during the period between i2o updates. So it is generally recommended that you Keep Sockets Open, except perhaps where it costs you money to maintain an open connection, or if infrequent i2o messages might cause your server's watchdog timer to timeout.

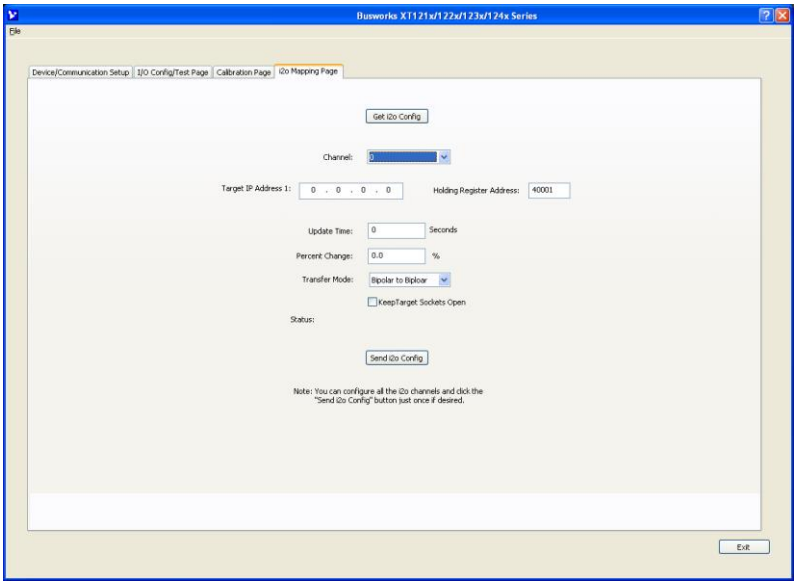
TIP: Note that the target output port channel may still be controlled independently via the network, but its level will be overwritten by subsequent mapped i2o messages when enabled. Thus, it is recommended that you do not try to control the i2o mapped output ports (target channels) directly, as this could create contention with the i2o control. Likewise, the USB Configuration software will not allow you to control output channels of i2o target output with an established client-server i2o connection.

To summarize, the source of an i2o message is an input model (master/client) and i2o is setup at the input module. The target of an i2o message is an analog output model (slave/server). The client will send its normalized input data to the server upon exceeding a percent change in value, and/or cyclically at an update time specified. The behavior of i2o is controlled by the configuration of Update Time, Percent Change, and Keep Target Sockets Open as illustrated in the following example combinations:

Update Time	Percent of span Change[1]	Keep Target Sockets Open	Behavior
0	0%	Enabled	i2o is OFF and no i2o messages are sent
0	0%	Disabled	i2o is OFF and no i2o messages are sent
0[1]	%Change>0.0%	Enabled	Input message is sent when %Change has been exceeded and while the socket is kept open
1-99sec	%Change>0.0%	Enabled	Input message is sent when %Change has been exceeded AND at every interval of Update Time and while the socket is kept open
1-99sec	0%	Enabled	Faster throughput w/Inputs sent every interval of Update Time and the socket is kept open
0[1]	%Change>0.0%	Disabled	Not recommended. Input sent only when %Change has been exceeded and the socket is opened and closed for every message.
5-65535sec	0%	Disabled	Input sent every interval of Update Time and the socket is opened and closed for every message
5-65535sec	%Change>0.0%	Disabled	Input sent when %Change is exceeded AND at every interval of Update Time and the socket is opened and closed for every message
T > 99sec	0%	Enabled	Invalid Configuration (Not Recommended) as it extends the time between messages over an open socket. Although this will send the Input every interval of Update Time, it is not recommended as it keeps the socket open needlessly with infrequent i2o updates.

[1]**Note:** It is not recommended to specify percent change without also specifying an update interval, as this can make successive i2o trigger levels vary widely.

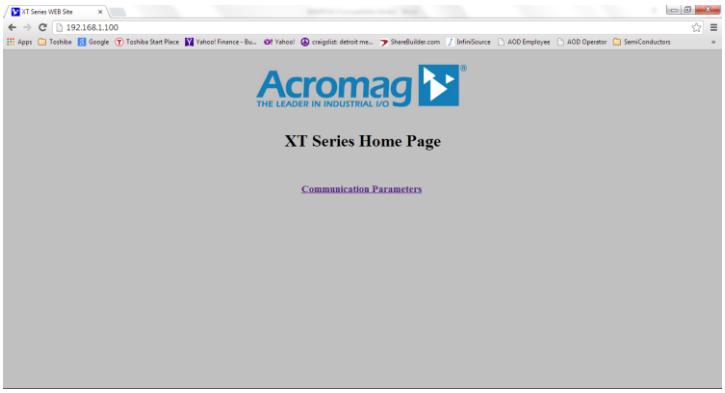
i2o Mapping Page…



Get i2o Config: Click here to retrieve the current i2o configuration from the unit. See the Status field for the status of this config message over USB. Note that the connected module's current i2o configuration was loaded automatically when you selected this screen.
Channel Scroll Bar: Select the specific input channel to be mapped to a target output channel on another unit at the IP and register address specified. It's best to configure each channel separately and efficiently send the entire i2o configuration, one time, by clicking the [Send i2o Config] button.
Target IP Address 1: The IP Address of a target output device (a compatible output module on the network). A single analog input can only be mapped to an output at one target IP address.

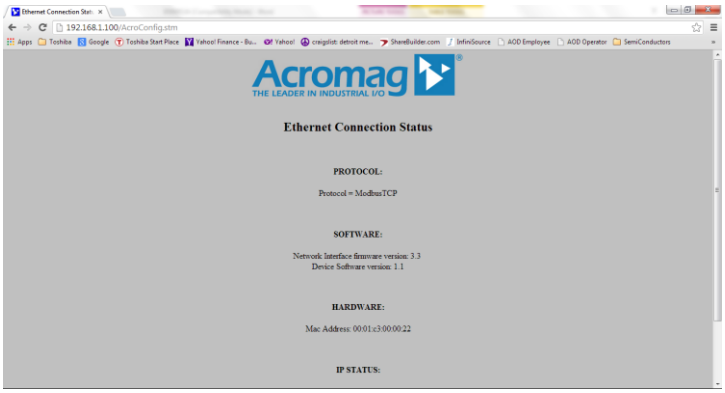
Holding Register Address: Memory Map address of the specific output channel of your i2o target to send this channel's normalized input data to**. IMPORTANT:** Always verify this register address setting with respect to your target module, or you could otherwise corrupt its operation by inadvertently overwriting its configuration at this address with i2o data.
Update Time Field: Specify a time from 1-65534 seconds between cyclical i2o messages, or 0 to turn cyclical i2o messaging OFF. If Target Sockets are kept open between messages, the minimum allowable update time is 1 second. If Target Sockets are not kept open, the minimum allowable update time is 5 seconds. If a non-zero Percent Change is defined and a time greater than 0 is specified, your messages will be sent upon matching or exceeding the Percent Change and at every interval of the Update Time specified. Set this time as wide as your application will allow in order to minimize network traffic. Timed updates are also be used with percent-of-change to improve the determinism of i2o messages triggered by a defined change in input value, as the value sent to the i2o output corresponds to the input level at the point of trigger, which is also the point at which the next percent-of-input change is calculated from (see below).
Transfer Mode: I/O channel ranges are either unipolar (from 0 up), or bipolar (zero crossing), and the specific transfer mode allows unipolar/bipolar conversions between the normalized i2o input data and the i2o target outputs. Mode selection essentially tells the unit how to scale zero of its range. That is, a bipolar to unipolar conversion will match -30000 at the i2o input to 0% of output at the i2o target, and +30000 at the i2o input to 100% at the output. A unipolar to bipolar conversion will set 0 of the i2o input to -100% at the output.
Keep Target Sockets Open Checkbox: Check this box to keep the communication socket of the target device open after sending i2o data to it. Keeping the socket open is recommended and helpful to obtain a faster i2o throughput time, as the open and close socket messages are not required for each i2o message, allowing an i2o message to be sent immediately along an already open socket. But you should not keep the socket open if you do not require frequent updates, as it does limit the bandwidth somewhat. Thus, it is recommended that you keep this box checked, unless your application requires that the socket be closed following a message, perhaps if keeping it open would incur additional cost, such as may be the case with wireless/cellular systems, or in peer-to-peer applications with long intervals between update messages. While still possible, it is not recommended to Keep Sockets Open and set update intervals greater than 99 seconds, as infrequent messages do not need to keep the socket open over their long i2o message intervals.
Status Field (USB): Gives the status of your USB i2o configuration message (i.e. returns the status of the write or read of the i2o configuration info only over USB).
Send i2o Config Button: Click this button to write your i2o configuration to the unit. You may click **[Send i2o Config]** for each group, one at a time, or you can more efficiently step through all 8 channels and then click the **[Send i2o Config]** button one time to write your entire i2o configuration. See the Status field for the status of this operation over USB.

Network Home Page



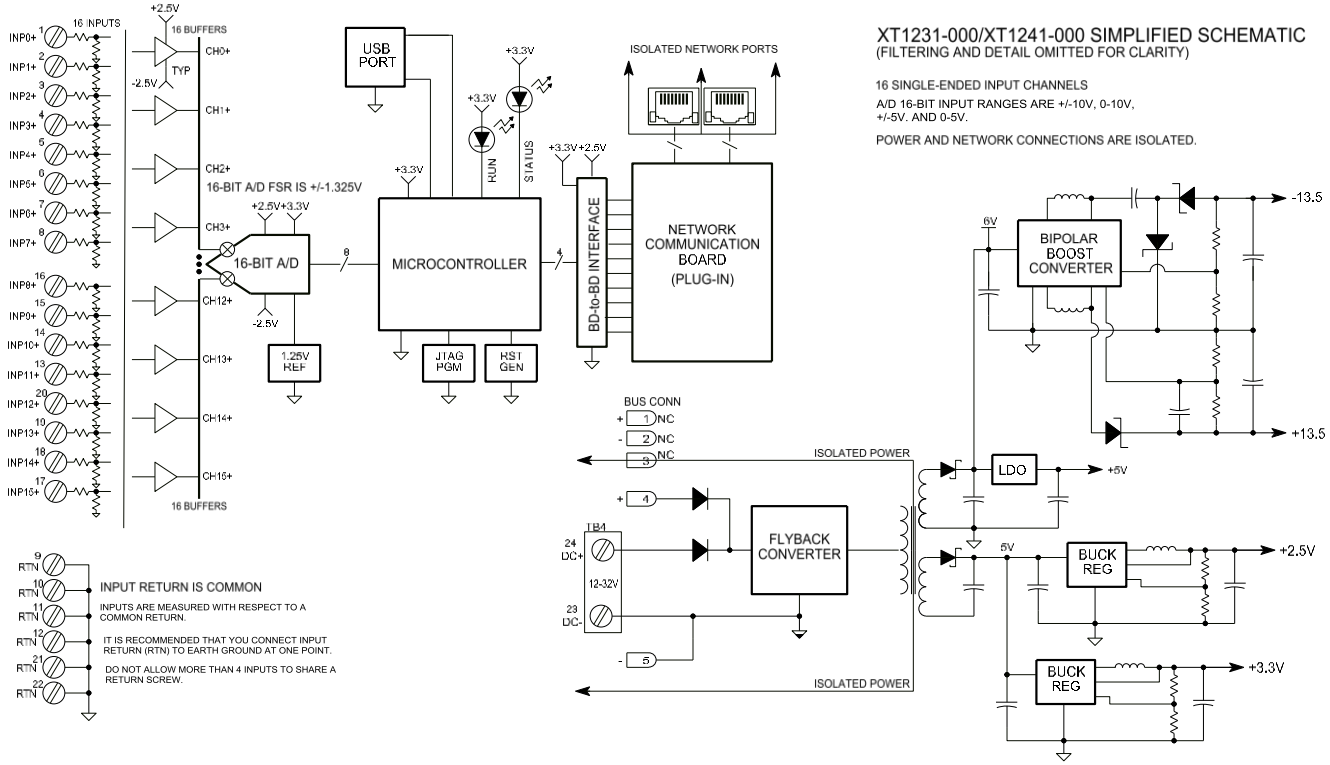
After configuring your unit for network communication via its USB port, you can identify the unit on the Ethernet network using a web browser directed to its IP address (you set this address on the Device/Communication Setup page of the USB Configuration Software for the unit, the default IP address is 192.168.1.100). This will access the home page of the unit similar to the first screen shown at left.

If you can view this page, this is useful for verifying your network connection to the unit.



You can click the “Communication Parameters” link of the Home Page to access the Ethernet Connection Status page shown in the second screen at left, which reviews the unit’s network communication parameters that are set over a USB connection to the device (scroll down this page to see all the communication parameter settings).

BLOCK DIAGRAM



How It Works

Key Points of Operation

- Unit is DC Powered
- Inputs & USB are Isolated from the network and power.
- Inputs are Single-Ended and share common.
- Inputs use 16-bit conversion.
- Input return is common with USB ground.

This model has sixteen single-ended input channels. It utilizes sixteen unity gain input buffers to 16 A/D inputs, which are separately multiplexed to a precision 16-bit A/D converter, under control of a 32-bit microcontroller. Inputs share 6 common return screws on the unit. Network communication specific to Modbus TCP/IP is handled by a separate controller on a mating communication board, serial-UART linked to the input board. Power for the input and network circuits is provided via an isolated flyback converter on the input board that operates from 12-32V. The unit is setup for network operation via a USB connection between a host PC and the microcontroller of the input board. The host PC runs model specific configuration software for the XT module. By using USB to configure the unit for network communication, it is not necessary to know the IP address of the unit in order to communicate with it, nor to change the IP address of your network card to an address in the module's subnet address domain. Refer to the block diagram above to gain a better understanding of how this model works.

The inputs & USB, network (each port), and power circuits are isolated from each other. The USB port ground is common to the input circuit return. The USB port ground of most PC's is also common to the USB cable shield and earth ground. Inputs could be grounded or ungrounded. For this reason, it is recommended that USB signals be isolated when connected to a PC to prevent a ground loop from occurring between the PC earth ground and a grounded input return, which could have a negative effect on the input measurement for severe ground loop currents.

About Modbus TCP/IP

IP (Internet Protocol) is the method by which data is sent from one computer (host) to another computer (host) on the network (Internet). In the Open Systems Interconnection (OSI) communication model, IP is in layer 3, the Networking Layer. Every computer or host on the Internet has an IP address that uniquely defines it from all the other computers or hosts on the Internet. IP is a connectionless protocol, which means that there is no continuing connection between end points (hosts) that are communicating. That is, each packet that travels across the Internet is treated as an independent unit of data without any relationship to any other unit of data.

Messages sent over the internet can be quite lengthy and are often divided into a number of smaller data packets. Every data packet contains both the sender's Internet address and the receiver's address. Each packet can, if necessary be sent by a different route across the Internet. As a result, the packets can arrive at their destination address in a different order. While the IP delivers the data packets, it is up to another protocol, the TCP (Transmission Control Protocol) to make sure that the packets are reassembled in the correct order.

So we see that the function of TCP is to ensure that all packets of data are received correctly, while IP makes sure that messages are correctly addressed and routed. Thus, TCP/IP refers to the functional combination of the Transmission Control Protocol and the Internet Protocol used to accomplish this and it allows blocks of binary data (packets) to be exchanged between computers, and reassembled in the proper order at their destination. TCP/IP is used world-wide and forms the foundation for the World Wide Web. But the TCP/IP combination does not define what the data means or how the data is to be interpreted, it is merely a *transport protocol*. For this module, Modbus is the *application protocol* and operates on the data, defining its meaning and purpose.

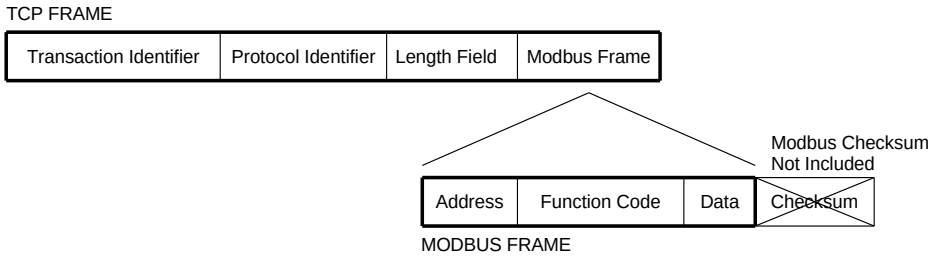
You can find more information on Modbus TCP/IP by visiting our web site and down-loading whitepaper 8500-765, Introduction To Modbus TCP/IP.

In contrast to the Transport Protocol TCP/IP, Modbus is an *application protocol*. It defines rules for organizing and interpreting data and is essentially a messaging structure that is independent of the underlying physical layer. It is freely available and accessible to anyone, easy to understand, and widely supported by many manufacturers.

The combination of both of these protocols forms Modbus TCP/IP. Modbus (application protocol) uses TCP/IP (transport protocol) over the Internet to carry the data of the Modbus message structure between devices. That is, Modbus TCP/IP combines a physical network (Ethernet), with a networking standard (TCP/IP), and a standard method of representing data (Modbus). Then, a Modbus TCP/IP message is simply a Modbus communication encapsulated in an Ethernet TCP/IP wrapper.

About Modbus TCP/IP…

In practice, Modbus TCP embeds a Modbus data frame into a TCP frame, without the Modbus checksum, as shown in the following diagram. The Modbus checksum is not used, as the standard Ethernet TCP/IP link layer checksum methods are instead used to guaranty data integrity.



Note that the Modbus address field is referred to as the *Unit Identifier* in Modbus TCP. In a typical slave application, the Unit ID is ignored and just echoed back in the response.

Modbus operation over Ethernet is essentially transparent to the Modbus register & command structure. The use of TCP/IP to travel over Ethernet does not change the meaning of the Modbus message.

IP Addressing

The IP address (Internet Protocol Address) uniquely defines a network host on the Internet, from all other hosts on the Internet, while the Internet Protocol (IP) is the method by which the data is exchanged between different hosts on the Internet.

A *Static IP Address* is as the name implies—static. That is, it is a unique IP Address that is assigned by a service provider and never changes.

A *Dynamic IP Address* is an address that is temporarily assigned to a user by a service provider each time a user connects.

A *Subnet* is a contiguous string of IP addresses. The first IP address in a subnet is used to identify the subnet, while the last IP address in a subnet is always used as a broadcast address. Addresses between the first and last subnet address make up the address domain of the subnet. Anything sent to the last IP address of a subnet is generally sent to every host on that particular subnet (e.g. to every address within its domain).

Subnets are further broken down into three size classes based on the 4 octets that make up the IP address. A Class A subnet is any subnet that shares the first octet of the IP address. The remaining 3 octets of a Class A subnet will define up to 16,777,214 possible IP addresses ($2^{24} - 2$). A Class B subnet shares the first two octets of an IP address (providing $2^{16} - 2$, or 65534 possible IP addresses). Class C subnets share the first 3 octets of an IP address, giving 254 possible IP addresses. Recall that the first and last IP addresses are always used as a network number and broadcast address respectively, and this is why we subtract 2 from the total possible unique addresses that are defined via the remaining octet(s).

TIP: The first node (0), node 10, and the last node (255 for our example) are typically reserved for servers and may yield poor results if used.

IP Addressing…

For our example, the default IP address of this module is 192.168.1.100. If we assume that this is a Class C network address (based on a default Class C subnet mask of 255.255.255.0), then the first three numbers represent this Class C network (or subnet) at address 192.168.1.0, the last number identifies a unique host/node on this network (node 100) at address 192.168.1.100.

The *Subnet Mask* is used to determine which subnet an IP address belongs to. The use of a subnet mask allows the network administrator to further divide the host part of this address into two or more subnets. The subnet mask flags the network address portion of the IP address, plus the bits of the host part that are used for identifying the sub-network. By convention, the bits of the mask that correspond to the sub-network address are all set to 1's (it would also work if the bits were set exactly as in the network address). It's called a mask because it can be used to identify the unique subnet to which an IP address belongs to by performing a bitwise AND operation between the mask itself, and the IP address, with the result being the sub-network address, and the remaining bits the host or node address.

For our Example, if we wish to further divide this network into 14 subnets, then the first 4 bits of the host address will be required to identify the subnetwork (0110), then we would use "11111111.11111111.11111111. 11110000" as our subnet mask. This would effectively subdivide our Class C network into 14 subnetworks of up to 14 possible nodes each.

With respect to the default settings of this module:
Subnet Mask 255.255.255.0 (11111111.11111111.11111111.00000000)
IP Address: 192.168.1.100 (10000000.00000001.00000001.01100100)
Subnet Address: 128.1.1.0 (1000000.00000001.00000001.00000000)

The sub-network address of 128.1.1.0 has 254 possible unique node addresses (we are using node 100 of 254 possible as our default). Nodes 0, 10, and 255 are typically reserved for servers and may yield poor results if used.

Dynamic Host Configuration Protocol (DHCP)

DHCP refers to the Dynamic Host Configuration Protocol and is a method used to assign temporary numeric IP addresses as required. A DHCP server maintains a pool of shared IP addresses which are dynamically assigned and recycled. When a DHCP device wants to use a TCP/IP application, it must request an IP address from the DHCP server. The DHCP server will check the shared supply, and if all addresses are in use, the server will send a busy signal to the client which tells it to try again later. Static IP addresses will ensure a connection every time, but dynamic addresses do not.

Domain Name System (DNS)

DNS denotes the Domain Name System or Domain Name Server and refers to the system used to associate an alphanumeric character string with a numeric IP address. The DNS is actually a distributed database of domain names and corresponding IP addresses. These servers contain information on some segment of the domain name space and make this information available to clients called *resolvers*. For example, the DNS allows us to use "Acromag.com" as an IP address rather than a complicated number string.

MODBUS REGISTERS

Modbus registers are typically organized into different reference types identified by the leading number of the reference address:

Reference	Description
0xxxx	Read/Write Discrete Outputs or Coils. A 0x reference address is used to drive output data to a digital output channel.
1xxxx	Read Discrete Inputs. The ON/OFF status of a 1x reference address is controlled by the corresponding digital input channel.
3xxxx	Read Input Registers (This Model). A 3x reference register contains a 16-bit number received from an external source—e.g. an analog signal.
4xxxx	Read/Write Output or Holding Registers. A 4x register is used to store 16-bits of numerical data (binary or decimal), or to send the data from the CPU to an output channel.

The "Reference" leading character indicated above is generally implied by the function code and omitted from the address specifier for a given function. The leading character also identifies the I/O data type. The "x" following the leading character represents a four-digit address location in user data memory.

This model only has analog input channels and no configuration is possible over the network (it uses a USB connection to reconfigure instead). As such, only 3xxxx addresses are utilized in reading analog signal data over the network for this model.

DIO models will typically denote the ON/OFF state of discrete inputs and/or outputs using a 1 or 0 value assigned to an individual bit of a 16-bit data word. Modbus allows sixteen 0x or 1x references per data word. With respect to mapping, the LSB of the word maps to the lowest numbered channel of a group and channel numbers increase sequentially as you move towards the MSB. Unused bit positions are usually set to zero.

I/O values are accessed via the 16-bit Input Registers or 16-bit Holding Registers given in the Register Map. Input registers contain information that is read-only. For example, the current input value read from a channel, or the states of a group of digital inputs. Holding registers contain read/write information that may be configuration data or output data. For example, the high limit value of an alarm function operating at an input, or an output value for an output channel.

Register Functions

For detailed information on Modbus, feel free to download our technical reference 8500-648, "Introduction To Modbus", at www.acromag.com. You can also find more information specific to Modbus TCP/IP by down-loading whitepaper 8500-765, "Introduction To Modbus TCP/IP".

Each module has a default factory configuration as noted in the SPECIFICATIONS section. Since your application will likely differ from the default configuration, your module will need to be reconfigured for your application. You may only reconfigure this module via a USB connection to it while running Acromag model-specific Configuration Software. There are no Modbus commands for accomplishing reconfiguration over the network.

Below is a small subset of standard Modbus functions that are supported by Acromag modules, along with the reference register address group that the function operates on. Use these functions to access these registers as outlined in the Register Map for sending and retrieving data.

The following Modbus functions operate on register map registers to monitor and control module I/O:

CODE	FUNCTION	REFERENCE
03 (03H)	Read Holding Registers	4xxxx
04 (04H)	Read Input Registers (This Model)	3xxxx
06 (06H)	Preset Single Register	4xxxx
16 (10H)	Preset Multiple Registers	4xxxx
17 (11H)	Report Slave ID (See Below)	Hidden Function

If an unsupported function code is sent to a module, exception code 01 (Illegal Function) will be returned in the response. If a holding register is written with an invalid value, exception code 03 (Illegal Data Value) will be returned in the response message. You may refer to the Modbus specification for a complete list of possible error codes.

Note that register mirroring used in some earlier Acromag models is not supported by Series XT models.

Register Functions…

XT1231-000/XT1241-000 Report Slave ID Example Response[1]

FIELD	DESCRIPTION
Unit ID	Echo Unit ID Sent In Query
Function Code	11
Byte Count	30
Slave ID (Model No.)[1]	36 (Hex)=XT1231-000 (16 Single-Ended Current In) 37 (Hex)=XT1241-000 (16 Single-Ended Voltage In)
Run Indicator Status	FFH (ON)
Firmware Number String (Additional Data Field)[1]	41 43 52 4F 4D 41 47 2C 58 54 3**1** 3**2** 3**3** 3**1** 2D **30 30 30** 2C 3**9** 3**3** 3**0** 3**0** 2D **32 32 31** 30 31 *32 33 34 35 41* 2C *30 31 32 33 34 35* ("ACROMAG,XT**1231**-**000**, **9300**-**221** *7 byte serial number&rev,six-byteMAC ID*")

[1]**Note:** The XT1231-000 slave ID is "36" and the firmware number is 9300-221. The XT1241-000 slave ID is "37" and the firmware number is 9300-222.

Data Types

Data Types and Description Used By These Models	
Analog Data (This Model)	A 16-bit signed integer with a maximum possible range of -32768 to +32767. Bipolar analog input ranges of this model are normalized to ±30000 or ±20000 (w/legacy support selected), which represents ±100% of the pre-defined range (or 0-30000/0-20000 representing 0-100% for unipolar ranges). For example, -100%, 0% and +100% are represented by decimal values –30000, 0, and 30000, respectively (or -20000, 0, and 20000 respectively). A full possible range is –109% (-32768 decimal) to +109% (+32767 decimal). Thus, a 0-20mA input would be represented by a register count of ±(Iin*27.4*32768)/ 1.325, or 0 to 13552 for this model. A bipolar voltage input model would be represented by a register count of ±(Vin_fs*0.12028*32768)/1.325, whereas ±10V corresponds to ±29480.

Register Map

The table at right outlines the register map for the Model XT1231-000 and XT1241-000 network I/O modules.

Modbus Read functions operate on these registers using the data types noted above (except for the Reset Slave and Report Slave ID functions).

Note the memory map for these models only covers read only input data. There are no registers for setting configuration variables, as this model is only configured via USB using its Configuration Software running on a Windows based Personal Computer before to connecting to the network.

Ref.	Addr.	Description	Data Type/Format
Input Registers (3x References, Read-Only)			
Normalized Channel Data Registers *The 16-bit Signed Integer Data stored here refers to the input range A/D count, after normalizing it to ±30000/0-30000, or ±20000/0-20000 (legacy i2o selected) for ±100%/0-100% of the input range.*			
30001	0000	CH 00 Data	16-bit Signed Integer Data
30002	0001	CH 01 Data	16-bit Signed Integer Data
30003	0002	CH 02 Data	16-bit Signed Integer Data
30004	0003	CH 03 Data	16-bit Signed Integer Data
30005	0004	CH 04 Data	16-bit Signed Integer Data
30006	0005	CH 05 Data	16-bit Signed Integer Data
30007	0006	CH 06 Data	16-bit Signed Integer Data
30008	0007	CH 07 Data	16-bit Signed Integer Data
30009	0008	CH 08 Data	16-bit Signed Integer Data
30010	0009	CH 09 Data	16-bit Signed Integer Data
30011	000A	CH 10 Data	16-bit Signed Integer Data
30012	000B	CH 11 Data	16-bit Signed Integer Data
30013	000C	CH 12 Data	16-bit Signed Integer Data
30014	000D	CH 13 Data	16-bit Signed Integer Data
30015	000E	CH 14 Data	16-bit Signed Integer Data
30016	000F	CH 15 Data	16-bit Signed Integer Data
30017	0010	Heart Beat Register	16-bit Unsigned Integer Data: An integer counter that increments by 1 for every host to network data transfer to help indicate if fresh data is present relative to the last data transfer, or if the unit has halted for some reason. This register counts from 0 to 65535 and wraps back around to 0.

TROUBLESHOOTING

Diagnostics Table

Before attempting repair or replacement, be sure that all installation and configuration procedures have been followed and that the unit is wired properly. Verify that 12-32V power is applied to the unit.

If your problem still exists after checking your wiring, power, and reviewing this information, or if other evidence points to another problem with the unit, an effective and convenient fault diagnosis method is to exchange the questionable unit with a known good unit.

Acromag's Application Engineers can provide further technical assistance if required. Repair services are also available from Acromag.

POSSIBLE CAUSE	POSSIBLE FIX
Green RUN LED does not light…	
Internal +3.3V rail has failed.	Return module for repair.
Green RUN LED flashes continuously…	
A network link has not been established.	Check your cable and switch/hub connections. Once a link is established, the green Run LED should not continue to blink but remain ON. If it continues to blink, then the cable/connection is bad or the firmware may have been corrupted.
Unit was not connected to network upon power-up, or network cable is bad.	The RUN LED will continue to blink as the unit initially hunts for a network link. Connect a network cable to the unit to complete initialization and stop the blinking. Note this only occurs for initial network communication following power-up.
Unit failed to boot firmware (Internal Firmware Failure).	A continuously flashing green Run LED can signify the unit has failed to initialize and may require repair, if you are sure you have a good network connection and proper power voltage. Return module to Acromag for repair/reprogramming.
Unit Fails to Start-up or Initialize…	
Input power voltage below 12V, or input supply is current-limited below twice the unit's current draw?	Check your power voltage and make sure that it is at least 12V and of sufficient capacity (select a current capacity at least 2x the maximum current draw of the unit).
Cannot Communicate With Module Over Network…	
Power ON at Module?	*Check power. Is Green Run LED ON?*
Using Wrong IP Address	You could either change the IP address of the module, or your host PC network card so that they both reside in the same address domain. The easiest solution is to connect to the unit via USB and change the IP address setting of the module.
Many Communication Errors…	
Is Cable segment longer than 100M?	The maximum distance between two nodes on an Ethernet network is limited to 100 meters using approved cable.
Correct Cable Type	Shielded CAT-5/5E cable, equivalent or better, is recommended.
Missing Earth Ground Connection?	Connect earth ground to power minus terminal at TB6-23.

Diagnostics Table…

POSSIBLE CAUSE	POSSIBLE FIX
Communication To Unit is Lost…	
Was communication interrupted by severe interference or shock?	Reset the unit by cycling power to it.
Adding another unit to network slows web page interaction considerably…	
Does each unit have a unique MAC address? *All units are normally shipped with a unique MAC address assigned from the factory. An error in shipment could release a unit with a default MAC address of 52:4F:42:45:52:54.*	Go to the Network Configuration Page of the USB Configuration Software and verify that each unit has a unique MAC address installed. This should always be the case. If you have 2 units with same MAC address, this will slow down communications considerably and you must contact the factory for MAC reassignment.
USB Software Fails to Detect Module…	
Bad USB Connection	Recheck USB Cable Connection
USB has not enumerated the device.	Use the reset button on the Acromag USB isolator to trigger renumeration of the module, or simply unplug and replug the USB cable to the module.
Communication or power was lost while USB was connected and the configuration software was running.	Close the current connection with the software, then select and re-open the module for communication (or simply exit the Configuration software and reboot it).
Cannot Communicate with Module via USB…	
A missing USB Isolator could cause a ground loop between a grounded input signal and earth ground at the connected Personal Computer's USB port.	Without a USB isolator, a ground loop is created between a grounded input signal source and earth ground of the PC USB port. For this reason, and for increased safety and noise immunity, it's best to connect to USB via a USB isolator. Use an isolator like the Acromag USB-ISOLATOR. Otherwise, use a battery powered laptop to configure the module which does not normally earth ground its USB port.
Input reading Erratic, Not operational, or Intermittent when Connected to USB…	
Unit fails to operate or exhibits an output shift…	
Missing USB isolation with grounded I/O signal source.	Even though the I/O is isolated from the network and power, if your input signal is already earth grounded, then connecting USB to the module may drive a ground loop between your input return and earth ground at the PC. Use USB signal isolation, or alternatively, you can connect to a battery-powered laptop/PC, which does not earth ground its USB connection.

Diagnostics Table…

POSSIBLE CAUSE	POSSIBLE FIX
Input Polarity is Wrong…	
Are your input terminals reversed?	Observe proper polarity for voltage inputs. Current can be input to the input (+) or input return terminals if a non-polarized range is selected (the ±20mA range).
Inputs Appear Noisy or Unstable…	
Have you grounded your inputs?	Connect one port return (RTN) terminal to earth ground if the input signal source is not already grounded.
Have you tried averaging? Is averaging set to 1? (This is a global channel setting, not per channel)	You can use the configuration software to set input averaging from 1-200 samples. A value of 1 is equivalent to no averaging. Higher averaging will help to minimize noise, but will increase the response time.
Status field of software screen indicates "Data Transfer Error", "Unknown Protocol" or "Timeout Error"…	
USB connection was opened before unit had completed its power-on initialization and established its network connection.	Wait ~30 seconds after powering-up unit before opening a USB connection via the configuration software. Turn power off to the unit, close the USB configuration software, repower the unit, then reboot the USB configuration software after the unit has completed power-on initialization and established its network connection.
i2o is not working…	
The upload was corrupted when i2o was written to the module.	Although rare, if you have rechecked your i2o configuration, but it fails to operate, try rebooting the module, or re-writing your i2o configuration (check your address settings, update time, percent change, etc).
i2o target is not working or working improperly…	
The Holding Register address at the i2o target is specified wrong and i2o messages have corrupted the target module's configuration.	Verify that you have set the holding register address correctly in the i20 configuration page for your target i2o module, as you would otherwise corrupt configuration data at the target module with i2o data.
Percent-of-Change i2o seems to be sending i2o messages at incorrect levels…	
The percent-of-change is calculated from the input level when i2o was initiated or the last i2o trigger point.	Percent driven triggers are calculated from the last i2o trigger point. Additionally specify a non-zero update time for a more predictable trigger level. This ensures subsequent i2o triggers occur at every interval of update time and percent driven triggers are calculated from a steady level between timed updates.

Service & Repair Assistance

This unit contains solid-state components and requires no maintenance, except for periodic cleaning and module configuration parameter (zero and full-scale) verification. The enclosure is not meant to be opened for access and can be damaged easily if snapped apart. Thus, it is highly recommended that a non-functioning module be returned to Acromag for repair or replacement. Acromag has automated test equipment that thoroughly checks and calibrates the performance of each module, and can restore firmware. Please refer to Acromag's Service Policy and Warranty Bulletins, or contact Acromag for complete details on how to obtain repair or replacement.

ACCESSORIES

Software Interface Package

Software Interface Package/Configuration Kit – Order XT-SIP

- USB Signal Isolator
- USB A-B Cable 4001-112
- USB A-mini B Cable 4001-113
- Configuration Software CDROM 5041-094

This kit contains all the essential elements for configuring XT network modules. Isolation is recommended for USB port connections to these models and will block potential ground loops between your PC and grounded input signals. A software CDROM is included that contains the Windows software used to program the unit (you can optionally download this software from www.acromag.com).

USB Isolator

USB Isolator – Order USB-ISOLATOR

- USB Signal Isolator
- USB A-B Cable 4001-112
- Instructions 8500-900

This kit contains a USB isolator and a 1M USB A-B cable for connection to a PC. This isolator and cable are also included in XT-SIP (see above).

USB A-B Cable

USB A-B Cable – Order 4001-112

USB A-B Cable 4001-112

This is a 1 meter, USB A-B replacement cable for connection between your PC and the USB isolator. It is normally included with the XT-SIP Software Interface Package XT-SIP and also with the isolator model USB-ISOLATOR.

Accessories…

USB A-mini B Cable

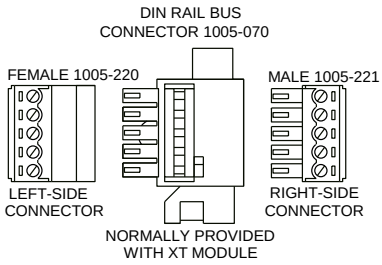
USB A-mini B Cable – Order 4001-113

- USB A-mini B Cable 4001-113

This is a 1 meter, USB A-miniB replacement cable for connection between the USB isolator and any ST, TT or XT module. It is normally included in XT-SIP.

Note that software for all XT Series models is available free of charge, online at www.acromag.com.

DIN Rail Bus Connector Kit



Bus Connector Kit for DIN Rail Bus Connection to Power, Model XTBUS-KIT

This kit contains one each of the following terminals

- DIN Rail Bus Connector 1005-070 for 22.5mm XT Modules.
- Left Side terminal block, female connector 1005-220.
- Right Side terminal block, male connector 1005-221.

Your module was shipped with the first item included in this kit, DIN Rail Bus Connector 1005-070, and this kit offers a spare. Left and right side terminal blocks that mate directly to the bus connector are included in this kit also. These terminals are used to optionally (or redundantly) drive power to Series XT modules via their DIN rail bus connector. This also allows modules to neatly and conveniently optionally share connections to Power along the DIN rail, instead of wiring power directly to the module's power screw terminals.

Low EMI Double-Shielded Patch Cable

Ethernet Patch Cable, 3 feet long, Model 5035-369
Ethernet Patch Cable, 15 feet long, Model 5035-370

This cable is used to connect a module to your network switch (like an Acromag 900EN-S005 or equivalent Ethernet switch), and is double-shielded for lower emissions and increased RFI resistance. It has been tested to lower radiated emissions of this product. It has a red, low-smoke, zero halogen jacket and bundles four pairs of 26AWG stranded cable. It uses a 100% foil shield beneath a 60% braided outer shield and includes an RJ45 plug at each end. It is electrically equivalent to L-Com TRD855DSZRD cable and can be obtained in other lengths directly from L-Com (http://www.l-com.com).

Double-shielded CAT5e or better cable is recommended for very noisy environments or in the presence of strong electrical fields. You may obtain shielded CAT-5e cable in other lengths and colors as required for your application from other vendors including L-com Connectivity Products, www.L-com.com, Pro-Link, www.prolink-cables.com, Regal, www.regalusa.com, and Lumberg, www.lumbergusa.com. The recommended L-com cable was used for CE Testing of this model.

SPECIFICATIONS

Model Number

XT1231-000 (16 Current Inputs)
XT1241-000 (16 Voltage Inputs)

Analog Input Module
Modbus TCP/IP Support
16 Single-Ended Input Channels
DC Powered
CE Approved
Includes UL/cUL Class I, Division 2 approvals

The XT1231-000 model denotes a 16 single-ended input channel module for DC current (as opposed to the eight channel XT1211 differential current model). The XT1241-000 model is a 16 single-ended input channel module for DC voltage (as opposed to the eight channel XT1221 differential voltage model). Single-ended refers to measuring the input signal relative to a common grounded return. These models operate over Ethernet using Modbus TCP/IP. They are setup and calibrated for network operation using USB. They represent additional members of the Acromag DIN-Rail mounted, "Busworks" family, in the XT Series. The trailing "-000" model suffix denotes DC powered w/ CE & UL/cUL Class I, Division 2 Approvals.

Reconfiguration of any XT model will require use of the XT-SIP configuration kit, ordered separately (see Accessories section).

Models are mounted on standard "T" Type DIN rail and include plug-in terminals. Power and excitation can be optionally (or redundantly) bussed along the DIN rail (see Power & Excitation Connections).

Analog Inputs

All input ranges are supported with a nominal bipolar and differential full-scale A/D range of ±1.325V for 16-bit bipolar conversion (±32768). XT1241 voltage inputs are first resistive-divided (12.1K/100.6K), then unity-gain buffered prior to the A/D (divider factor is 0.115019x). For XT1241 models, you may select DC voltage ranges of ±5V, ±10V, 0-5V, or 0-10V, on a per channel basis. Current inputs are shunted through 27.4Ω resistors to a common return in XT1231 models and the unit accepts current ranges of ±20mA, 0-20mA, 0-11.17mA, and 4-20mA, such that ±20mA DC drives ±0.548V full-scale through unity-gain buffers to the A/D. All selectable input ranges are normalized to ±30000 for ±100% of range, or optionally to ±20000 for ±100% of range (w/ legacy support). Positive current or voltage is delivered to the (+) input terminal and returned at the common return (RTN) terminal.

Unit must be wired and configured for the intended input type and range (see Connections section for details). The following paragraphs summarize this model's input types, ranges, and applicable specifications:

DC Current (XT1231 Only): Configurable for ±20mA, 0 to 20mA, 4-20mA, and 0-11.17mA DC nominal input ranges. A precision 27.4Ω (0.125W) current sink resistor converts the input current to a voltage that is processed by the A/D converter. XT1231 units utilize the ±1.325V A/D range with ±20mA DC driving ±0.548V full-scale to the A/D. An optional external sensor is required to monitor AC current signals (Acromag Model 5020-350). The AC sensor drives 0 to 11.17mA DC to the module (see Table 1 below for scaling to AC current).

DC Voltage (XT1241 Only): Bipolar DC voltage ranges of ±10V, 0-10V, ±5V, and 0-5V are driven to the A/D through resistive dividers (0.115019x factor) and unity-gain buffers. The A/D has a native 16-bit nominal bipolar range of ±1.325V. You may select DC input voltage ranges of ±5V, ±10V, 0-5V, or 0-10V, on a per channel basis.

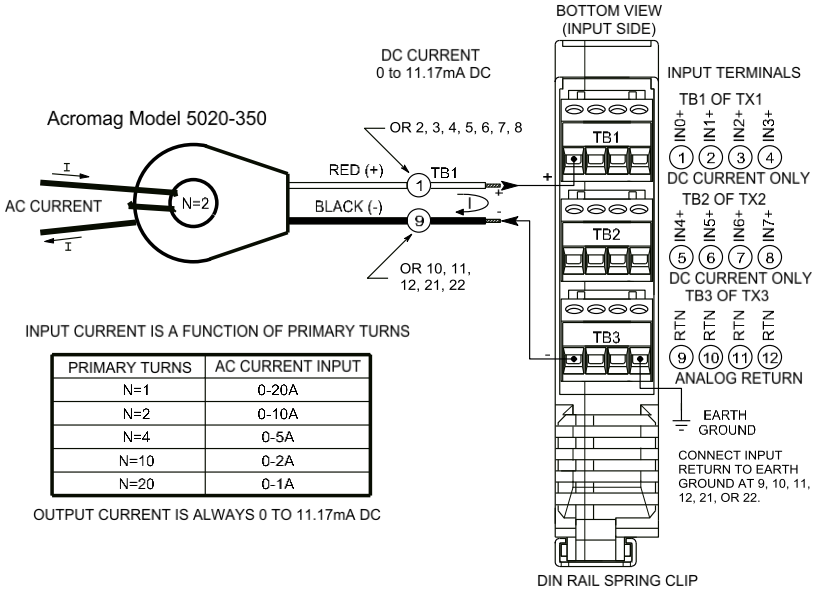
Analog Inputs…

Input Overvoltage Protection: Bipolar Transient Voltage Suppressers (TVS), 5.6V clamp level typical (XT1231), or 18V clamp level typical (XT1241). Inputs also include current-limited (series resistance) diode clamps to the ±2.5V rails.

Optional AC Current Sensor (Model 5020-350, for AC Current Input to XT1231): The 5020-350 sensor can be connected to any of the input terminals of this model for AC current sensing, and is a toroidal instrument transformer that converts the sinusoidal 50-60Hz AC current signal into a low level DC milliampere signal of 0 to 11.17mA. The input AC current range is a function of the number of turns placed through the toroid as shown in Table 2 below. This sensor is isolated and requires no calibration or adjustment. When used with the XT1231 module, it also facilitates current input isolation channel-to-channel, and redundant current input isolation with respect to the network and power of this transmitter.

The output wires of this sensor are polarized with red as plus (+) and black as minus (-). Normally these output wires are attached to one end of a user supplied cable, while the other end connects to the current input terminals of this module, similar to that shown below.

MODEL XT123x-000 WIRING TO AC CURRENT SENSOR 5020-350



INPUT CURRENT IS A FUNCTION OF PRIMARY TURNS

PRIMARY TURNS	AC CURRENT INPUT
N=1	0-20A
N=2	0-10A
N=4	0-5A
N=10	0-2A
N=20	0-1A

OUTPUT CURRENT IS ALWAYS 0 TO 11.17mA DC

Table 2: Optional AC Current Sensor Turns & Range

AC Current Input Range	Primary Turns	Sensor Output (Red/Black Wires)
0 to 20A AC	1	0 to 11.17mA DC
0 to 10A AC	2	"
0 to 5A AC	4	"
0 to 2A AC	10	"
0 to 1A AC	20	"

AC Input Burden: A function of the wire gauge resistance used for primary turns (the current carrying wire being monitored).

Analog Inputs…

AC Current Sensor to Transmitter Wiring Distance: 400 feet maximum for 18 gauge wire. Other wire gauges can be used as long as the resistance of both wires is less than 5Ω.

AC Input Overload: The AC current sensor will withstand overload conditions as follows:

- 20 times full scale for 0.01 seconds.
- 10 times full scale for 0.1 seconds.
- 5 times full scale for 1.0 second.

Input Resolution (Minimum Discernible Change): Unit has a fundamental 16-bit A/D input range of ±1.325V, which defines 1 lsb equal to 2.65V/65536, or 40.436uV/bit. That is, the A/D of this model divides the input signal range into a number of parts that can be calculated by subtraction using the expression for A/D counts as (Vin_eff/1.325)*32768 for its bipolar ±1.325V A/D full-scale input range with 16 bit corresponding to ±32768 counts. Vin_eff is the effective DC input voltage of this model after the input voltage divider (0.115019x on XT124x voltage units), or the current input shunted through 27.4Ω on XT123x models (0.548V @20mA into 27.4Ω for XT1231 Models). The resultant raw A/D count is then normalized using a bipolar conversion scheme of ±30000 (bipolar ranges), or ±20000 (bipolar ranges w/legacy support), each corresponding to ±100% of input range. That is, -100%, 0% and +100% are represented by decimal values –30000, 0, and 30000, respectively, or -20000, 0, 20000 respectively (w/legacy support). The effective input resolution for a given range is normally the lowest resolution of either the A/D conversion, or its normalized value. For this model, the effective resolution is dominated by that of the A/D converter (shaded values below). An indication of nominal input resolution is expressed as the number of parts between the input range low and high endpoints shown in the table below.

Input Resolution for XT123x-000 Input Ranges[1]

RANGE Into 27.4Ω	±20mA (±0.548V)	0-20mA (0-0.548V)	4-20mA (0.1096-0.548V)	0-11.17mA (0-0.30606V)
Raw A/D	±13552 (1 part in 27104)	0-13552	2710-13552 (1 part in 10842)	0-7569
Resolution	1.476uA/bit			
PPM	36.9ppm	73.8ppm	92.2ppm	132.1ppm
Normalized	±30000	0-30000	0-30000	0-30000

Normalized Resolution for XT1241 Input Ranges[1]

RANGE	±10V	±5V	0-10V	0-5V
Raw A/D	±28445 (1 part in 56890)	±14222 (1 part in 28444)	0-28445	0-14222
Resolution	351.6uV/bit			
PPM	17.6ppm	35.2ppm	35.2ppm	70.3ppm
Normalized	±30000	±30000	0-30000	0-30000

[1]XT123x current inputs use a 27.4Ω shunt resistor to drive ±0.548V at ±20mA to a 16-bit ±1.325V input A/D. XT124x voltage ranges are coupled to the A/D after a 12.1K/100.6K resistive voltage divider (0.12028x). All input ranges are normalized to ±30000 for ±100%, and 0-30000 for 0-100% (or ±20000 for ±100%, and 0-20000 for 0-100% with legacy support enabled).

Analog Inputs…

Input Accuracy: Better than ±0.05% of span typical, ±0.1% maximum. This includes the effects of repeatability, terminal point conformity, and linearization, but does not include sensor error.
Input Measurement Temperature Drift: Better than ±50ppm/°C (±0.0050%/°C).
Input Update/Conversion Rate: Your response time will vary as averaging is increased. The fastest response time with no averaging (averaging set to 1) is less than 1ms typical for both models.
Input Reference Test Conditions: ±20mA (XT123x) or ±5V (XT124x) input; ambient temperature = 25°C; 24VDC supply.
Input Impedance: 105.2KΩ minimum (XT124x input divider), or 27.4Ω (XT123x shunt resistor).
Input Over Voltage Protection: Bipolar Transient Voltage Suppressors (TVS), with a clamp level approximately 24V (XT124x), or 7.5V (XT123x). This is followed by series resistance (voltage divider) current-limited clamping diodes to the ±2.5V rails at each input lead, then unity-gain input buffers.
Input Calibration: Inputs can be calibrated manually by driving the input channel with a precision reference current or voltage signal source.
Input Analog to Digital Converter (A/D): A 16-bit delta-sigma converter, Texas Instruments ADS1158IRTC, connected in bipolar mode with a 1.25V reference, yielding a 16-bit A/D input range of ±1.325V corresponding to a count of ±32768.
Input Filter: Normal mode filtering fixed per input type.
Input Filter Bandwidth: -3dB at 25KHz, typical, no averaging.
Input Noise Rejection (Common Mode): Better than -110dB @ 60Hz, typical with 100Ω input unbalance.
Input Cable Length: I/O port interface cables should not exceed 30m in length for rated performance.

Power

Power Supply (Connect at TB6 terminals 24 & 23, and/or via the DIN Rail Bus): 12-32V DC SELV (Safety Extra Low Voltage), 2.8W max. Observe proper polarity. Reverse voltage protection is included. Unit can be redundantly powered by connecting power to both the power terminals on the unit at TB6 and DIN rail bus at TB7 (these inputs are diode-coupled to the same point in the circuit). Current draw varies with power voltage as follows.

SUPPLY	XT123x/124x-000 CURRENT
12V	207mA Typical / 228mA Max
15V	163mA Typical / 180mA Max
24V	103mA Typical / 113mA Max
32V	77mA Typical / 85mA Max

CAUTION: Terminal voltage at or above 12V minimum must be maintained to the unit during operation. Do not exceed 36VDC peak to avoid damage to the unit.
Power Supply Effect: Less than ±0.001% of output span effect per volt DC change.

USB Interface

IMPORTANT – USB Isolation is Recommended: The inputs of these modules are isolated from each network port and DC power, but the input return is also common to its USB connection.

Most Personal computers (except DC powered laptops) connect their USB signal and shield ground to earth ground. Without a USB isolator, an earth grounded USB connection could drive a ground loop with any earth ground also applied at its input return, which might interfere with operation. For this reason, we recommend that you always use a USB isolator when making a USB connection to prevent a potential ground loop from negatively affecting performance. Otherwise, in the absence of USB isolation, a battery powered laptop could be used to connect to the unit, as the laptop does not normally connect to earth ground.

Unit includes a mini USB-B socket for temporary connection to a PC or laptop for the purpose of setup, reconfiguration, and trouble-shooting. However, USB isolation is recommended when connecting to a unit that may also be connected to grounded I/O signals, because the USB connection often provides its own earth ground. Note that this model does not utilize power from USB and must already have DC power connected to it when connecting to USB.

CAUTION: Do not attempt to connect USB in a hazardous environment. Module should be setup and configured in a safe environment only.

Data Rate: USB 2.0 compatible, up to full-speed at 12Mbps.

Cable Length/Connection Distance: 5.0 meters maximum.

Driver: No special drivers required. Uses the built-in USB Human Interface Device (HID) drivers of the Windows Operating System (Windows XP or later versions only).

USB Connector: 5-pin, Mini USB B-type socket, Hirose UX60-MB-5S8.

PIN	DEFINITION
1	+5V Power (Transient protected, but not used by this model)
2	Differential Data (+)
3	Differential Data (-)
4	NC – Not Connected
5[1]	Power Ground (Connects to Signal Ground via ferrite bead)
SHLD[1]	Signal Ground (Connects directly to Signal Ground)

[1]**Note:** Most Host Personal Computers (except battery powered laptops) will connect earth ground to the USB shield and signal ground.

Transient Protection: Unit adds transient voltage protection to USB power and data lines when connected, but the unit does not use USB power.

USB Cable Length/Connection Distance: 5.0 meters maximum.

Ethernet Interface

Connector: Dual, shielded RJ-45 sockets, 8-pin, 10BaseT/100BaseTX. The metal shield circuit of the network connectors is isolated and capacitively coupled to the input power minus terminal via an isolation capacitor.

Network-to-Network Isolation: Network ports are additionally isolated from each other and will withstand a 1000VAC dielectric strength test for 1 minute without breakdown.

Wiring: Unit includes auto-crossover for MDI or MDI-X cables.

Protocol: Modbus TCP/IP w/USB Configuration.

IP Address: Default mode static IP address is 192.168.1.100.

Port: Up to 10 sockets supported, uses port 502 (reserved for Modbus).

Data Rate: Auto-sensed, 10Mbps or 100Mbps.

Duplex: Auto-negotiated, Full or Half Duplex.

Compliance: IEEE 802.3, 802.3u, 802.3x.

Modbus TCP/IP Protocol Support: Up to 10 sockets may be selected for Modbus TCP/IP. The unit includes a built-in web page for ID on the network using a standard web-browser, but configuration of the unit is only possible using configuration software running on a Windows PC and connected via USB.

Ethernet Interface…

Communication Distance: The distance between two devices on an Ethernet network is generally limited to 100 meters using recommended copper cable. Distances may be extended using hubs, switches, or fiber optic transmission. However, the total round trip delay time must not exceed 512 bit times for Ethernet collision detection to work properly.
Port Status Indicator: Yellow LED of the network connector indicates network activity--Ethernet connection is busy and traffic is present.
Address: The module IP address can be preset (static) by the user via USB. At startup, it can be loaded from internal non-volatile memory, or it can be automatically acquired via a network server using DHCP (Dynamic Host Configuration Protocol).

Before you can communicate with any module over Ethernet, you must set your network interface to a valid IP address in the address domain of the module. Refer to Acromag Application Note 8500-734 for example instructions on how to change the IP address of your PC network interface card in order to talk to an Acromag module. For this model, it is easier to use a USB connection to a host computer running the Configuration Software to change the IP address setting of the module to an address in the address domain of your network interface card.

Enclosure & Physical

General purpose plastic enclosure for mounting on 35mm "T-type" DIN rail.
Dimensions: Width = 22.5mm (0.9 inches), Length = 114.5mm (4.51 inches), Depth = 99.0mm (3.90 inches). Refer to Mechanical Dimensions drawing.
I/O Connectors: Removable plug-in type terminal blocks rated for 12A/250V; AWG #26-12, stranded or solid copper wire.
Program Connector: USB Mini B-type, 5-pin. See USB Interface.
Case Material: Self-extinguishing polyamide, UL94 V-0 rated, color light gray. General purpose NEMA Type 1 enclosure.
Circuit Board: Military grade fire-retardant epoxy glass per IPC-4101/98 with humi-seal conformal coating.
DIN-Rail Mounting: Unit is normally mounted to 35x15mm, T-type DIN rails. Refer to the DIN Rail Mounting & Removal section for more details.
Shipping Weight: 0.5 pounds (0.22 Kg) packed.

Environmental

These limits represent the minimum requirements of the applicable standard, but this product has typically been tested to comply with higher standards in some cases.

Operating Temperature: -40°C to +70°C (-40°F to +158°F).

Storage Temperature: -40°C to +85°C (-40°F to +185°F).

Relative Humidity: 5 to 95%, non-condensing.

Isolation: Input channels and USB (as a group), network (two ports), and power circuits are all isolated from each other for common-mode voltages up to 250VAC, or 354V DC off DC power ground, on a continuous basis (will withstand 1500VAC dielectric strength test for one minute without breakdown). This complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified. The network ports will withstand a 1000VAC dielectric strength test port-to-port for one minute without breakdown.

Installation Category: Suitable for installation in a Pollution Degree 2 environment with an Installation Category (Over-voltage Category) II rating per IEC 1010-1 (1990).

Shock & Vibration Immunity: Conforms to: IEC 60068-2-6: 10-500 Hz, 4G, 2 Hours/axis, for sinusoidal vibration ; IEC 60068-2-64: 10-500 Hz, 4G-rms, 2 Hours/axis , for random vibration, and IEC 60068-2-27: 25G, 11ms half-sine, 18 shocks at 6 orientations, for mechanical shock.

Electromagnetic Compatibility (EMC)

Minimum Immunity per BS EN 61000-6-2:

1) Electrostatic Discharge Immunity (ESD), per IEC 61000-4-2.
2) Radiated Field Immunity (RFI), per IEC 61000-4-4.
3) Electrical Fast Transient Immunity (EFT), per IEC 61000-4-4.
4) Surge Immunity, per IEC 61000-4-5.
5) Conducted RF Immunity (CRFI), per IEC 61000-4-6.

This is a Class A Product with Emissions per BS EN 61000-6-4:

1) Enclosure Port, per CISPR 16.
2) Low Voltage AC Mains Port, per CISPR 16.
3) Telecom / Network Port, per CISPR 22.

WARNING: This is a Class A product. In a domestic environment, this product may cause radio interference in which the user may be required to take adequate measures. Refer to the EMI Filter Installation drawing in the Electrical Connections section of this manual to install ferrite cable clamps that help to reduce radiated emissions. The use of low EMI double-shielded Ethernet cable is also helpful in curbing emissions.

Agency Approvals

Electromagnetic Compatibility (EMC): CE marked, per EMC Directive 2004/108/EC. Consult Factory.

Safety Approvals: UL Listed (USA & Canada). Hazardous Locations – Class I, Division 2, Groups A, B, C, D Hazardous Location or Nonhazardous Locations only. These devices are open-type devices that are to be installed in an enclosure suitable for the environment. Consult Factory.

Reliability Prediction

Reliability Prediction

MTBF (Mean Time Between Failure): MTBF in hours using MIL-HDBK-217F, FN2. *Per MIL-HDBK-217, Ground Benign, Controlled,* $G_B G_C$

XT1231-000	MTBF (Hours)	MTBF (Years)	Failure Rate (FIT)
25°C	463,547 hrs	52.9 years	2,157
40°C	345,200 hrs	39.4 years	2,897
XT1241-000	**MTBF (Hours)**	**MTBF (Years)**	**Failure Rate (FIT)**
25°C	458,991 hrs	52.4 years	2,179
40°C	338,846 hrs	38.7 years	2,951

Configuration Controls

Software Configuration Only via USB

Although this module normally operates using Modbus TCP/IP over Ethernet, it can only be setup, calibrated, and configured via USB. This is convenient since it you do not have to already know its IP address setting, or set your IP address to a compatible domain address, in order to talk to it. Its behavior as a 16 Channel analog input module is determined via a temporary USB connection to a host computer or laptop running a Windows-compatible configuration software program specific to the model. This software provides the framework for digital control of all configuration & calibration parameters, and this information is stored in non-volatile memory.

LED Indicators:

RUN (Green) – Located at front panel. Constant ON if power is on and unit is OK. Flashes ON/OFF during initialization & network connection. If flashing continuously it could indicate a network cable issue, or a possible firmware issue.

ST (Yellow) – Located at front panel. Turns ON if any input signal is over/under range.

ACT (Yellow) – Located on RJ45 port connector itself. Indicates Ethernet activity--the Ethernet connection is busy and traffic is present.

Refer to Configuration Step-by-Step in the Technical Reference section of this manual for detailed information on available software control of this model.

REVISION HISTORY

Release Date	Version	EGR/DOC	Description of Revision
15-APR-14	A	BC/KLK	Initial Acromag "A" Release.
24-APR-14	B	BC/ARP	Remove references to IEEE Floating Point numbers on page 34.
10-SEP-14	C	CAP/ARP	Added UL Mark (removed pending, per ECO #14H030).
13-OCT-14	D	BC/CAP	Added MTBF Data.